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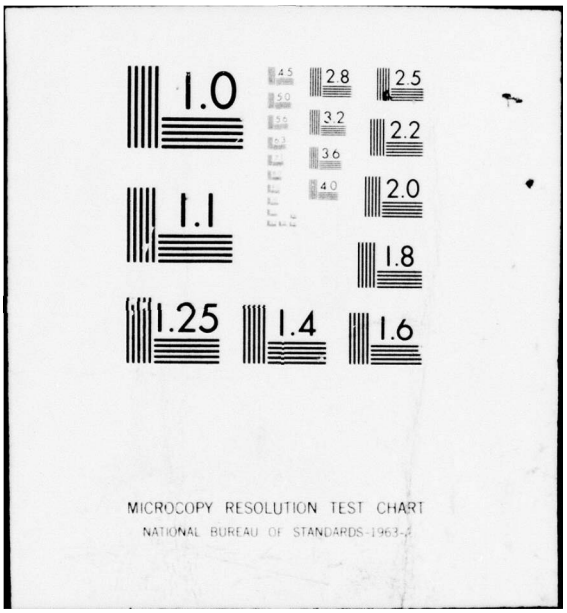
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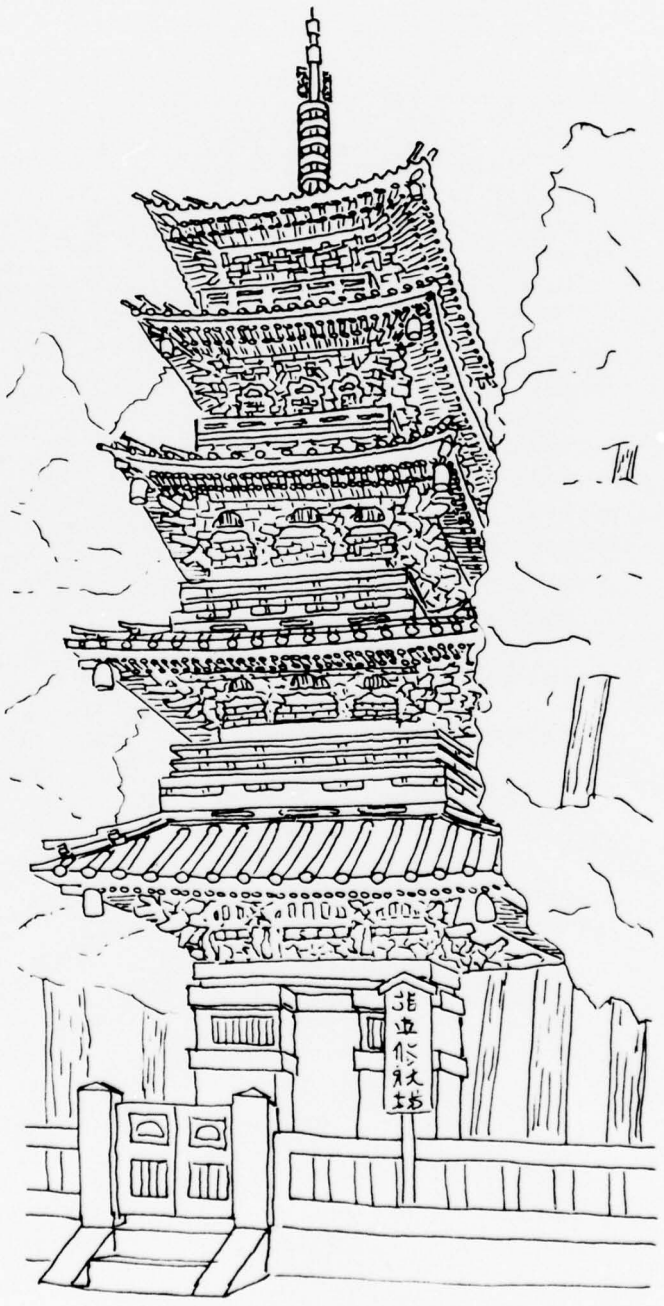

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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be

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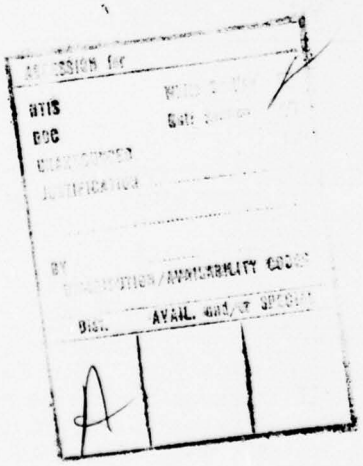

DEPARTMENT OF THE NAVY
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SCIENTIFIC LIAISON GROUP
AMERICAN EMBASSY
APO SAN FRANCISCO 96503

We are gratified by the response to our initial issue of the ONR Tokyo Scientific Bulletin and are particularly indebted to those who offered advice and recommendations. The most frequent comments dealt with disciplines and topics suggested for future coverage, and we will assuredly give these serious consideration. As noted, we have a small in-house staff and must rely upon visiting scientists for additional inputs. From time to time Japanese scientists will also be invited to submit reviews of research. In this vein, we issue an open invitation to American scientists on professional visits to the Far East to consider contributing their findings for possible inclusion.

The plan for the Bulletin was and remains to publish relatively brief items and to issue separate monographic reports of lengthy articles. We are not yet prepared to implement this, however, and for the present an occasional monographic report will appear in the Bulletin.

In the development of this new publication, a difficult task was achieved upon going to press with the first issue. From now on the objective is to improve. In support of this goal we welcome the reactions and counsel of our readers.

Morton A. Bertin
Scientific Director

GUEST CONTRIBUTORS TO THIS ISSUE

Kanji Ono is a professor of engineering at the University of California, Los Angeles. His research interests include strengthening mechanisms and phase transformations in metals and physical acoustics.

Leon Lasdon is a professor of operations research at Case Western Reserve University. His areas of specialty include mathematical programming algorithms and applications and the use of systems analysis in court, police, and other urban applications.

J. W. Morris, Jr. is associate professor of metallurgy, Department of Material Science and Engineering, the University of California, Berkeley. His principal research interests are in the design of new alloy steels for advanced engineering needs.

THE COVER: The elaborately decorated five-story pagoda was drawn by Justin L. Bloom, Counselor for Scientific and Technological Affairs of the American Embassy in Tokyo. It stands just inside the entrance to Toshogu Shrine at Nikko, probably the most ornate Shinto Shrine in Japan. The pagoda is 35 meters tall and was built of wood in 1818. The drawing was done by pen and ink on paper and reduced to two-thirds of its original size by photo-offset lithography.

CONTENTS

FIRST JAPAN INSTITUTE OF METALS INTERNATIONAL SYMPOSIUM ON "NEW ASPECTS OF MARTENSITIC TRANSFORMATION"

K. Ono

This international symposium was organized by the Japan Institute of Metals as the first of a series of symposia to be held every two to three years. It was held in Kobe, Japan, May 10-12, 1976 and attracted nearly 160 metallurgists from 10 countries. A total of about 70 invited and contributed papers were presented. Because of two simultaneous sessions, however, I missed nearly half of those papers. Invited papers by Professors Nishiyama, Cohen and Wayman reviewed various aspects of martensitic transformation, understanding for which has been developed over the past 50 years. Professors Kurdjumov, Christian, Fujita, Shimizu and Tamura presented invited papers focusing on more specific topics: carbon redistribution in ferrous martensites, correlation between O-lattice, elasticity and crystallographic theories, soft-mode related mechanisms, structures of stress-induced martensites and the thin-plate morphology, respectively. Kurdjumov cited the findings of abnormal c/a ratios in freshly quenched martensites and proposed to explain via [211] (111)—twin formation in austenite. It seems that Mössbauer results on carbon positions are in disagreement and that more direct experimental support is needed for the proposed mechanism. Christian emphasized that O-lattice approach is essentially similar to crystallographic theory and that strain energy consideration is unnecessary or inappropriate. He maintained that martensites can be considered often as very thin plates, for which strain energy minima can be obtained analytically. Basically, Christian appears to consider the martensitic transformation to be an interfacial phenomenon. Fujita introduced a 6-layer monoclinic structure as an intermediate step between fcc and bcc phases and proposed it as the operating mechanism for soft phonon mode processes. It is an interesting proposal and is worthy of further study in conjunction with crystallographic theory and lattice invariant shear. Shimizu presented findings on Cu-Al-Ni alloys where stress varied the martensite structures induced. While only uniaxial stress was considered, their results pointed up interesting relationships between different martensites in a single alloy. Tamura's talk dealt with experimental features of thin-plate martensites, having completely twinned internal structures and smooth interfaces and forming at the lowest M_s temperatures. He considered the flow stress to be the controlling factor in morphological variations.

Our paper was given on the first session and followed by active discussions. After commenting on Christian's criticisms, some of which are valid in pointing out the limitation of elasticity theory, it was emphasized that an energetic criterion is a workable basis with specific examples in Ti and Ti alloys. Strain energy minimization was also discussed by Mori in their elegant treatment of Zener ordering.

Tamura's presentation was preceded by Ansell, who showed that stacking fault energy controls martensite morphology in Fe-Ni-Cr alloys. For twinned martensites, Okamoto analyzed crossing, kinking and branching via phenomenological theory. Khachaturyan considered faults and (111) twins in austenite as sources of morphological changes.

Second day topics on thermoelastic martensites and nucleation-growth mechanisms are widely discussed subjects, but the size of martensite nuclei was again brought up. The most impressive presentation of that morning was the electron micrographs of carbon clusters shown by Nagakura, who fully utilized diffraction theory in confirming the nature of 10A size clusters. A couple of papers on reverse austenite transformation were interesting for the potential of using it in structural refinement. A detailed analysis of isothermal transformation in Fe-Ni alloys was also presented.

Strength of martensite was still the important topic to many attendees and attracted a large audience. Kelly presented strength, internal friction and electron microscopy data on ferrous martensites confirming an

earlier concept proposed by D. V. Wilson; i.e., martensite strength arises from retained dislocations. Inexplicably, however, Kelly gave no credit to the earlier proposal. Krauss correlated microstructural observations to fracture behavior of high carbon martensites, and Hirai presented cryogenic properties of 304 and 316 stainless steel welds.

The final session on internal structures heard Wayman and Maki on thin plate martensite in Fe-Ni-C alloys. They reported that observed twin widths varied while maintaining the twin fraction at 0.43. Observations on dislocations in the wake of receded martensite boundaries were interesting but puzzling. Kajiwara correlated reproducible martensites in Cu-Zn to retained dislocation substructures and Hosomi showed stages of martensite to austenite reversion and austenite recrystallization in 18 Ni maraging steel and Fe-Ni alloys.

This symposium was most successful in reviewing the achievements of the past half century of martensite research and in bringing together many researchers working in the field. No break through was obvious either in theory or in applications, but discussions on concrete ideas relating to soft phonon mode were useful. Morphological variations still need to be correlated to the strain energy minimization concept, which we proposed. The latter was recognized as a new approach in the invited talks by Christian and by Wayman, but further work on ferrous martensites appears essential for it to be widely applicable. On the other hand, it was disappointing to have so few truly practical applications of martensitic transformation. One short session on thermomechanical treatment was cancelled and discussions on microstructural control via transformation were limited to those of Jin and Morris and a few others. Aside from these deficiencies, the organizing committee headed by Professor Shimizu is to be congratulated for its outstanding effort in bringing forth an excellent opportunity for international information exchange.

POST SYMPOSIUM VISITS

TECHNICAL RESEARCH CENTER
NIPPON KOKAN K.K.
1-1 Minamiwatarida, Kawasaki

This research laboratory is located within the Keihin Works complex, a short taxi ride away from JNR Kawasaki station. Dr. K. Horikawa is the director. During this visit I conferred with Mr. J. Tanaka, Dr. H. Inagaki, J. Tanaka and Mr. C. Ouchi. J. Tanaka and Ouchi have been concerned with HSLA steels, especially on controlled rolled products. Dr. Inagaki has been working on hydrogen permeation and stress corrosion cracking in HSLA steels. They belong to Steel Product Section. Mr. J. Tanaka is with Welding Section and works on HSLA steel welding. The main subject of discussions was lamellar tear of weldments of HSLA steel plates, which is of critical importance in large-scale welded steel structures.

Recent Japanese work on this subject has been summarized in a preprint of the 37-38th Nishiyama Memorial Lectures of the Iron and Steel Institute of Japan (published last year, in Japanese). These and more recent NKK results were discussed. It has been clearly established that excellent correlation exists between the sulfur content and the susceptibility to lamellar tear in HSLA steel. These steels are typically Aℓ-killed and controlled rolled. Stretched MnS bands are apparently responsible. Their efforts at NKK are directed toward controlling MnS morphology, while improving the conventional mechanical property levels. Hydrogen permeation and stress corrosion research utilizing acoustic emission have recently been initiated in conjunction with the above mentioned research.

We have agreed to conduct a joint project on the effects of MnS morphology on ductility, acoustic emission behavior and lamellar tear in an HSLA steel. My earlier experiments indicated the decohesion or cracking of MnS to be the major source of acoustic emission in Mn-C type HSLA steels and these new tests should clarify such findings.

FUNDAMENTAL RESEARCH LABORATORIES
NIPPON STEEL CORPORATION
1618 Ida, Kawasaki

This organization is headed by Dr. S. Nagashima and is located near Hiyoshi station of the Toyoko line. After talking with the director, I discussed our new theory on martensite with Professor Nishiyama, who had just returned from Kobe. Subsequently, Dr. Nagumo, Deputy General Manager of the First Section, described their recent work on amorphous metals, Fe P_{13} C_7, Fe Cr_{10} P_{13} C_7 and other Fe-P-C alloys with different P/C ratios. These were produced by centrifugal and twin roll methods. They determined hydrogen diffusivity in amorphous Fe P_{13} C_7 to be about 10^{-11} cm^2/sec at room temperature with the activation energy of 2 to 4 kcal/mole. Amorphous metals absorbed as much as 100 ppm at room temperature, which made the metal very brittle. However, no hardness change due to hydrogen was found. Fracture surfaces changed from typical vein-type to cellular with increasing hydrogen content (more than 10-20 ppm). Since the utility of amorphous metals depends on the stability, they have also examined the relation between the tendency of formation and that of crystallization by varying the P/C ratio. The crystallization temperatures were essentially unchanged. They also noted that homogeneous crystallization of alpha ferrite plus Fe_3C always occurred. One of their dreams is to make amorphous materials directly from molten pig iron, thereby eliminating costly steelmaking and processing steps.

Drs. Hayami and Furukawa, Deputy General Manager and Chief Researcher, respectively, of the Second Section, briefed me on the development of new high strength cold rolled steels. This class of steels has two phase structures; about 30% martensite and the remainder ferrite. Typical composition is 0.1%C, 0.3-1.5%Si, 1-1.6%Mn. It is formed after continuous annealing in the alpha/gamma range followed by air cooling and achieves the tensile strength of 400 to 800 MPa (58 to 116,000 psi) with good ductility. This is a remarkable accomplishment, as no expensive alloying additive is used. Martensitic transformation of high carbon austenite, which forms during continuous annealing, is utilized very effectively. This development is the most impressive technical feat encountered during my trip to Japan. Dr. Nagashima later commented that a similar product had been also developed at NKK.

Another important technical development concerns stress corrosion behavior of austenitic stainless steels. Dr. Hosoi and Mr. Abe of the Third Section described stress corrosion characteristics of Metal-bearing Solution Refined (MSR) stainless steel. MSR process was recently developed at Nippon Steel. It is a modification of ESR and utilizes Ca-containing slags. This process reduced P, O, S and N down to the 10 to 30 ppm range. Mr. Abe indicated that chlorine-induced transgranular SCC can be virtually eliminated by reducing P and Mo. Reduction of O and S was also effective. MSR treated 300 series stainless required no Mo to prevent pitting corrosion. Intergranular caustic corrosion was prevented by lowering carbon below 0.01%. He also described their accelerated test procedure for reactor applications. It consists of creep stressing (at strain rate of 10^{-6}/sec) in pressurized pure water at 300° C with dissolved oxygen.

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
TOKYO INSTITUTE OF TECHNOLOGY
Ookayama, Meguro, Tokyo

Literal translation of the name of this school is Tokyo Technological University, but the official English name reflects their admiration for MIT and Cal Tech. Its main campus is located just outside Ookayama station of the Mekama and Denentoshi lines. The undergraduate enrollment is about 3000, including almost all engineering fields, mathematics, physics and chemistry.

I visited Professor T. Mori and also gave a seminar on "Strain Energy Consideration in Martensitic Transformation." Discussions with Professor Mori focused on the applicability and limitation of Eshelby theory. His recent work on periodically distributed eigen-strain appears to be even more suitable for the treatment of martensitic transformation.

RESEARCH LABORATORIES
KAWASAKI STEEL CORPORATION
1 Kawasaki, Chiba

I spent a morning at this laboratory with Dr. K. Fujimoto, Deputy Director, as the host. Dr. K. Sanbongi is the director. The laboratory is located within the Chiba Works, about 3 miles south of JNR Chiba station (50 minutes by train from Tokyo station).

Dr. Imanaka and Mr. Shimizu described their preliminary experimental results on the use of an electron energy analyzer in conjunction with a scanning transmission electron microscope. They will acquire a new JEM microscope with a field emission gun and an ultra high vacuum specimen chamber (10^{-8} torr, -196°C to 1000°C heating and cooling capability) together with an energy analyzer. Their current instrument is capable of 0.5 eV resolution at 100KV. Spatial resolution is 100A diameter for the plasma loss, which is of the order of 10 to 30 eV and sensitive to alloy composition. Their initial interest is to clarify grain boundary segregation.

Mr. Hirai explained their research on lamellar tear mechanisms based on a report (J. Tsuboi and M. Hirai, Lamellar Tear and Its Evaluation, part I, October 28, 1974, Kawasaki Steel Corporation). They employed acoustic emission testing together with an argon-filled welding chamber. It was concluded that two types of lamellar tear mechanisms exist; one is due to thermal stress immediately after welding, opening inclusions followed by hydrogen induced cracking, and the other is delayed fracture due to hydrogen initiated at the root or toe of weldment. For steels with more than 0.01%S, sulfide inclusions are the primary origins of lamellar tear. For steels with less than 0.01%S, clusters of oxide-silicate inclusion are responsible. The addition of REM or Ti cannot eliminate lamellar tear, when globular sulfides exist as clusters. From their work, it appears that the detection of lamellar tear via acoustic emission is difficult since most cracking takes place just after welding and would be hard to discriminate against slag cracking noises.

Dr. Sano described their amplitude distribution analysis system of acoustic emission signals and its application to martensitic transformation. Samples were 18Ni-3Mn-0.32C, 18 Ni-1Mn-0.86C and 30Ni-0.34C alloys. These form dislocated, mid-rib twin and twinned thin plate martensites, respectively. The peak amplitude distribution can be described by a power-law. The exponent of 3.2 to 4.7 was obtained, when the entire transformation range was analyzed. Different regions of transformation should yield interesting variations. Correlation with size distribution is also important.

Finally, Mr. Y. Iwasaki briefly explained the highlight of his recent paper (Acta Cryst. A32, 59-65, 1976) on general theory of 0-lattices. He applied theories of groups and numbers to different classes of lattices and deduced the existence of transcendental lattice. Reciprocals of the classes of lattices were also discussed. At present, application of the general theory to phase transformation is still a difficult task. However, as Christian pointed out at the martensite symposium in Kobe, interface coherency is an important basis for martensitic transformations.

DIELECTRIC LOSS IN POLYMERS AT LOW TEMPERATURES

E. A. Kearsley

The dielectric loss in polymers at low temperatures has recently become of great technological interest because of the possibility of designing transmission lines or other electrical equipment to operate in a superconducting mode. Polyethylene is widely used as a particularly useful insulator, but it has been observed to have an unexpectedly high loss at liquid helium temperatures. This loss is often ascribed to antioxidant in the polyethylene but W. A. Phillips and also R. A. Carson in England have interpreted the anomalous loss as arising from a phonon-assisted tunneling of protons in hydroxyl groups (which are accidentally present in the polymer). Others have proposed different mechanisms for the loss.

At the Department of Applied Physics, University of Tokyo, dielectric loss measurements have been made at temperatures from 1.5 to 4.2°K over a frequency range from 10 Hz to 10 kHz on (1) melt-crystallized films of high density polyethylene, (2) single crystal mats of high density polyethylene, (3) films of low density polyethylene and (4) films of ethylene-vinyl alcohol copolymers.

An isochronal curve of dielectric loss of a typical high density polyethylene shows a fairly sharp loss peak at about 170° (the so-called γ peak) generally ascribed to local modes of amorphous segments to which carbonyl groups are attached. At lower temperatures the loss decreases to a minimum at about 70° K and then shows a sharp upswing below 10° K. It is this upswing which is the anomalous low temperature loss. More usually dielectric loss data are plotted against frequency at a fixed temperature. When a clear peak appears in such a plot, the frequency of the maximum is taken to be a relaxation frequency. The dependence of relaxation frequency on temperature is an indication of the underlying molecular mechanism. Thus, when the relaxation frequency depends linearly on absolute temperature, a quantum tunneling process is suspected, whereas a thermally activated process would show a linear relationship between the logarithm of relaxation frequency and the reciprocal of absolute temperature. From the data on polyethylene, the University of Tokyo group concludes that the low temperature loss is indeed due to a tunneling process. Furthermore, the insensitivity of this loss to the density of carbonyl groups (induced by oxidation) leads them to conclude that the process does not result from carbonyl groups. The γ peak, on the other hand, is very sensitive to the density of carbonyl groups. From comparisons of the data on high density and low density polyethylene, it can be seen that both the crystalline and the amorphous phases contribute to the dielectric losses, with a narrow and a broad dispersion curve respectively.

To examine the assumption that hydroxyl groups are the source of the losses, the Tokyo group observes that ethylene-vinyl alcohol copolymers must, by implication, show a high level of dielectric loss from the same cause, both in the crystalline and the amorphous state. Indeed, the high level losses are observed with the expected broad distribution. A calculation of the dependence of this loss on the mole fraction of vinyl alcohol monomer predicts a maximum loss at a mole fraction of 0.12. In fact, their measurements indicate a strong maximum at 0.075, but it is not difficult to explain this discrepancy in terms of the crudities of the model and the neglected interactions between neighboring hydroxyl groups. The calculation is very encouraging, and the Tokyo group therefore undertook a quantitative analysis of the loss induced by a hydroxyl group in the orthorhombic lattice of polyethylene. The calculations agree with observed values on assuming lattice distortions consistent with x-ray analysis. The density of the hydroxyl groups in high density polyethylene is estimated to be $10^{16}/cm^3$. The group sees the study of anisotropy in dielectric loss of oriented samples as a route to more insight into these loss mechanisms.

Some of this work has been published in Reports of Progress in Polymer Physics in Japan. Further publication can be expected in the near future. The group of researchers consists of Okimichi Yano, Koichiro Saiki, Seigo Tarucha and Yasaku Wada of the Department of Applied Physics, University of Tokyo.

DENTAL SEALANTS AT THE INSTITUTE FOR MEDICAL AND DENTAL ENGINEERING

E. A. Kearsley

The Institute for Medical and Dental Engineering is attached to the well-known Tokyo Medical and Dental University. It is housed in a new building about a city block from the University and University Hospital complex. It has a staff of 60. Although most of the research staff is engineers, developmental work is done in close cooperation with the Faculties of Medicine and Dentistry. The main task of the Institute is to develop novel devices and materials for medical and dental use. This is done with eight research divisions: Metallurgy, Inorganic Materials, Organic Materials, Medicinal Chemistry, Applied Mechanics, Electronic Engineering, Instrumentation Engineering and Biocybernetics.

Professor Eiichi Masuhara, head of the Division of Organic Materials, is internationally known for his work with tri-n-butylborane (TBB) as a catalyst for polymerization of methyl methacrylate (MMA). With the use of TBB, graft polymerization of MMA onto collogen occurs initiated by the presence of water and oxygen. A dental filling material and an orthodontic adhesive based on this principle have been marketed. TBB, by the way, is a highly flammable substance originally developed as a rocket fuel!

Dr. Nobuo Nakabayashi is a polymer chemist in the Division of Organic Materials who has carried on this work. He has a good command of English and an interest in things American which reflects an earlier postdoctoral appointment at Yale. In an effort to develop a sealant for pits and fissures in teeth, he studied modifications of the TBB-monomer system. Adhesive strength with tooth enamel (rather than dentine) and stability in service are necessary for this application. Tooth enamel contains less collogen than does dentine and is thus a more difficult proposition. After several trials of different materials, Dr. Nakabayashi finally settled on a compound of 97% MMA and 3% 2-hydroxy-3-β-naphthoxypropyl methacrylate (HNPN). This compound, if used with the simple procedures he developed, produces bonds of amazing strength and stability. Although the exact reason for the success of this formulation has not been proved, it probably has to do with the "fit" of the configuration of hydrophobic and hydrophilic segments on a molecular level.

Dr. Nakabayashi showed me an exhibit he calls his "Mt. Fuji," since all visitors must view it. On display were several samples of bovine teeth with PMMA blocks supporting 400 gram weights. The area of the glued joint was only 0.3 cm^2 and everything was immersed in water at 37°C. These samples had been under test for four years and no failure had occurred yet. Some older samples of PMMA rods glued to ivory were as much as 11 years old, but these ivory samples were treated with 100% MMA (without HNPN) and were only immersed in water, not under constant stress. Tensile breaking loads for these ivory samples were about 300 Kg/cm^2 and the break would often occur within the PMMA and not at the ivory interface. Nakabayashi's Fuji-san is not as beautiful as the original, but it is impressive.

An adhesive filling material, an orthodontic adhesive and a dental pits and fissures sealant are already commercially available as a result of this research. Dr. Nakabayashi continues the research, but his principal interest has now shifted to developing an improved artificial kidney. In general, the Division of Organic Materials seeks biocompatible polymers for medical and dental applications.

RHEOLOGY OF POLYMERS AT THE INSTITUTE FOR CHEMICAL RESEARCH, UJI CAMPUS, KYOTO UNIVERSITY

E. A. Kearsley

The Department of Polymer Chemistry of Kyoto University is justly known as the biggest and most important center for polymer studies in Japan. That fact says a good deal, since throughout Japan a remarkable amount of excellent polymer science is practiced. Some part of that reputation, however, belongs to the Institute for Chemical Research of Kyoto University which is actually at Uji, a distance of a dozen kilometers or so from the main campus in Kyoto. Among the twenty laboratories of this Institute are four polymer groups (which cooperate closely with the Department of Polymer Chemistry): Polymer Solutions, Polymer Crystals, Polymer Separation and Characterization, and Fiber Chemistry.

Recently I visited the Polymer Solutions Laboratory of the Institute for Chemical Research. Although Professor Michio Kurata, who heads the laboratory, was not present on the day of my visit, Professor Kunihiro Osaki was. He directs a very active study of the non-linear visco-elasticity of polymer solutions. Since his studies of the last few years mesh closely with my own and those of my colleagues at the National Bureau of Standards (NBS), we had a most congenial discussion.

About five years ago, this polymer solutions group built several instruments and began a systematic study of the non-linear visco-elastic behaviour of well characterized samples. The equipment they had designed made it possible to do simple stress-relaxation experiments on concentrated polymer solutions in shear, well up into the non-linear range. As far as I know, this is the only apparatus specifically designed to do stress-relaxation experiments on polymer solutions. A cone and plate geometry was used with a 20% solution of polystyrene (1.8×10^6 molecular weight) in chlorinated biphenyl (Arochlor). They were able to represent the relaxation modulus of this sample as a product of a shear amplitude factor times a time-dependent factor equal to the linear modulus. It is well known that such a representation is only approximate, and in this case also, the separability worked only for times greater than about 20 seconds. Normally, for small deformations of a polymer solution where linear visco-elastic theory applies, it is known that isothermal stress-relaxation curves taken at different temperatures can be superimposed by shifting them along the time axis (actually, the curves should be "reduced" by dividing by density times absolute temperature). This procedure, known as "time-temperature superposition," expresses the temperature dependence of the relaxation processes and the shift factor, a_T, is often associated with frictional processes occurring within a long-chain polymeric molecule. The Uji group was able to establish that time-temperature superposition worked for their sample even in the range of non-linear behaviour and, furthermore, that a_T was independent of the amplitude of strain. Incidentally, the Uji group observes (as have others) that for some materials the non-linear effects increase with time, which suggests a caveat for researchers who "establish linearity" by quick tests.

More recently, the Uji group has worked with a set of solutions of polystyrene in diethyl phthalate to study the effects of concentration and molecular weight. Generally polystyrene is used for research on the effects of molecular weight because relatively narrow distributions of molecular weight are now commercially available, while for most other polymers, time-consuming and expensive fractionation would be required. Osaki and his colleagues used five narrow fractions ranging from 1.23×10^6 to 7.62×10^6 in molecular weight and at concentrations from 0.112 to 0.329 g/cm^3. The most interesting feature of the stress-relaxation of these polystyrene solutions is a curious plateau in the shear modulus curves, suggesting a highly non-linear source since it usually appears for only a limited range of shear. The Cox-Merz equation was found to seriously underestimate the non-linear effects of rate of shear for materials which exhibited this curious plateau. The Cox-Merz

equation is an approximate empirical equation setting the steady-shear viscosity of a material equal to the absolute magnitude of the complex dynamic viscosity measured from the response to sinusoidal shearing stress. It is often assumed that the Cox-Merz relation is a good general approximation. An interesting criterion for the appearance of this plateau was noted – the plateau appeared only for samples for which the product of concentration and molecular weight exceeded 10^6 grams/cc. Surely, any good polymer theorist worth his salt can make something of that.

Currently in polymer rheology circles, much significance is attached to the build-up of stress in a sample suddenly subjected to a steady shear. Presumably this tells something about the strength of "entanglements" or other temporary links between the long-chain molecules. The Uji group has also used this experiment. As is well known, under certain conditions, the shear stress develops in time through a maximum, the so-called "stress-overshoot." The Uji group did measurements on the various molecular weights and concentrations used in the earlier stress-relaxation experiments. They found that at low concentrations or low molecular weights a rather sharp overshoot occurred whereas, otherwise, the overshoot was broad and diffuse. Although with some samples they were unable to produce a noticeable overshoot within the shear-rate range available, the criterion for the appearance of the curious plateau comes to mind again. The group analyzed these results and the results of stress relaxation after cessation of steady shear in terms of the simple stress-relaxation data taken earlier. They found that the Bernstein-Kearsley-Zapas theory (a theory according to which the stress for any history can be calculated as an integral of stress relaxation data) describes these results rather well. While the agreement was not perfect, it was certainly a much better fit than can be done with models incorporating a strain-rate dependent relaxation spectrum. (Modesty forbids that I make the point more strongly.) The principal known failing of the BKZ theory is that the predicted overshoot is low, but it does occur at the correct time. In fact, the Uji group has twostep stress-relaxation data that also do not correspond to predictions of the simple BKZ model and this is presumably another aspect of the same failing of the theory. Zapas at NBS using PIB has seen the same thing. Resolution of these discrepancies seems to be sought generally in allowing the relaxation times of the polymer (the material clock in the BKZ model) to be affected by the history of the deformation. My personal bias is to look for a pressure or stress effect on the material clock rate. However it is done, unfortunately, the simplicity of an honest single-integral theory is lost. That is equivalent to saying that a complete set of single-step stress-relaxation data is not enough to characterize the material. At the Department of Polymer Chemistry in Kyoto, some substantial results have recently been worked out on constitutive models with just such "memories" which are dependent on the scalar invariants of the stress or the rate of strain. These models are based on the old Lodge network theory, but with non-constant network creation rate and cross-link loss probability. Undoubtedly the Uji group will examine these results next.

Recently, the Uji group has looked at suddenly applied steady shear and cessation of steady shear on a 20% solution of styrene-butadiene-styrene (SBS) triblock copolymer in cetyl chloride. Block copolymers are particularly interesting from a polymer physics point of view, since chemically different blocks of polymers can be grafted into well defined parts of long-chain molecules. In the case of this SBS block copolymer, time-temperature superposition did not work on the viscosity-rate of shear curve and the Cox-Merz equation also failed. On the other hand, the BKZ theory predicted the isothermal behavior reasonably well from stress relaxation data but, of course, not the temperature dependence. Even I am surprised.

SHOTEN OKA AND THE FUJIHARA PRIZE

E. A. Kearsley

I first met Professor Shoten Oka in 1962 when he was at Tokyo Metropolitan University. At that time he and his colleague, the late Misazo Yamamoto, were perhaps unique in Japan in approaching rheological problems from a fundamental physical point of view. Professor Oka has a most modest, soft-spoken manner so that one is immediately comfortable with him. I am surprised to discover that he still remembers in detail a little talk I gave on a specialized problem in viscometry. His interests even then, however, were turned towards biorheology. In subsequent years as I encountered him again at International Rheology Congresses, his work more and more reflected this interest. Recently, I heard that Professor Oka has been awarded the Fujihara Prize for 1976 for his work on the mathematical theory of blood flow in veins and arteries. This was the first I had heard of the Fujihara prize (often called Fujiwara prize) which is little known in the West but carries great prestige in Japan along with a substantial purse. Its recipients form a very distinguished company indeed, and it deserves to be better known outside Japan.

The Fujihara Foundation of Science was founded in 1959 by Ginjiro Fujihara, "the Paper King of Japan," on the occasion of his 89th birthday. He had served many years as president of the paper company which in the 19th century introduced the manufacture of Western style paper to Japan. Through the foundation he set up a fund for the award of an annual prize to a Japanese citizen who had made outstanding contributions to the advancement of science. Mathematics, physics, chemistry, engineering, biology, agronomy and medicine are specifically included in the definition of science. A Committee of Selection was set up, currently composed of the President of the Japan Society for the Promotion of Science, a former President of Tokyo University, and other similarly distinguished scientists. Since its founding, the endowment of the foundation has been considerably increased by further donations so that in 1974 the rate of awards was increased to two per year. This year Atsushi Okabayashi, a research medical doctor and professor emeritus of Chiba University, also received a prize for his work on delayed sensitization pathology. By my rather arbitrary count, the prize has now been awarded twice in medicine, twice each in pure mathematics, pure physics, biology (including once in paleontology), agronomy, and biophysics and four times in chemistry.

Along with the increased rate of prizes, the Fujihara Foundation in 1974 inaugurated an international seminar for the promotion of science to take place annually in Hokkaido in September. This seminar is sponsored through the Japan Society for the Promotion of Science and each year a particular topic is selected. In 1974 the topic was "Poly (ADP-Ribose) and ADP-Ribosylation of Protein" and in 1975 "Physics of Highly Excited States in Solids." The symposium for 1976 is on "Theories and Ab-initio Calculations of Molecular Electronic Structure."

Professor Oka, recently retired from Tokyo University, is still very active. He is a guest professor at Kyorin University School of Medicine and does collaborative research and consulting with several other institutions. He took an active part in a symposium on Hemorheology and another symposium on Hemorheological Aspects of Thrombosis in conjunction with two international congresses held this September in Japan. It is good to hear that he has earned such a prestigious prize and I take pride in it as a fellow rheologist.

OPERATIONS RESEARCH IN THE FAR EAST

Leon S. Lasdon

INTRODUCTION

This paper contains information obtained during my lecture tour of the Far East, June 1–July 15, 1976. The tour was sponsored by the Office of Naval Research, with the objective of information exchange. I visited universities and industries in Japan, Taiwan, Hong Kong, the Philippines, and Singapore, lecturing on a variety of operations research topics, mostly involving optimization applications, algorithms, and software. The presentation is chronological, giving my recollections of discussions at the various institutions visited. I am indebted to Professor Susumu Morita of the Case Western Reserve University Operations Research Department and to Professor Yoshio Kuratani of Tsukuba University for their comments on the initial drafts of this paper.

JAPAN

TOKYO INSTITUTE OF TECHNOLOGY

The Department of Systems Science at Tokyo Institute of Technology covers a broad range of systems topics, including parts of operations research, systems engineering, and computer science. The department is part of the graduate school at Nagatsuta and offers masters degrees. These fields are also studied in other departments, e.g., Industrial Engineering, Control Engineering, and Information Science. Many professors are listed in more than one of these departments, all of which give Ph.D. degrees. Significant expansion is occurring in the Industrial Engineering Department. In most others, the influx of students has leveled off after tripling in the 1960's. There are now about 8,000 students at Tokyo Institute of Technology.

Faculty research includes work on general systems theory (Professor Takahara). This is based on the foundation laid down in (1). Takahara sees it as a way of modeling aspects of systems which we now regard as "qualitative." He also hopes to develop a theory which will deal with approximations made in modeling systems. This will require defining a topology on models, so that we can measure how "far" one is from another.

Other work (Professor Ichikawa) deals with preferences of decision makers. To measure the incidence of intransitive preferences, Ichikawa had students make sequences of paired comparisons and observed a statistically significant incidence of intransitivity. Objects compared had multiple attributes. Some of his work deals with how best to display a vector of attributes to a decision maker. An example is interactive optimization, in which the analyst views information on the progress of an algorithm (in this case, Benders decomposition method applied to a warehouse location problem) and makes some decisions on how the method is to proceed. Some similar work has been done by J. B. Rosen at the University of Minnesota.

Other work described to me had an artificial intelligence flavor, dealing with the role of humans in systems and the psychology of decision making. There was strong interest in better understanding these aspects and computer modeling of them.

There is a recently formed "working group on fuzzy systems," whose Report No. 1, "Summary of Papers on General Fuzzy Problems" is dated November, 1975. The roster in the report lists 39 members from companies, universities, and research laboratories. Some of the papers in the report deal with fuzzy sets (in the sense of Zadeh), fuzzy integrals, and automata, while others are on man-machine communication, models of social

behavior and conflict, and systems analysis of "soft" problems, e.g., opening the sports facilities of a firm to the public.

KEIO UNIVERSITY

Systems and O.R. studies occur at Keio in the Departments of Instrumentation (Professor Shimizu), Mathematical Engineering (Professor Tone), Electrical Engineering, and perhaps others. Masters and Ph.D. degrees are given, as well as undergraduate courses. There is quite a bit of interest in optimization. Professor Shimizu has written two books on this topic (dynamic optimization and mathematical programming) and translated a third (by Professor Lasdon) into Japanese. He is interested in decomposition and in multi-objective optimization. One of his papers deals with a block-diagonal mathematical program, possibly nonlinear, with coupling constraints. It incorporates the coupling constraints into the objective by exterior penalty functions and uses the Frank Wolfe method (which linearizes the objective) to achieve a decomposition. This is applied to multi-commodity flow problems with nonlinear costs. Another deals with a three level situation, in which the first level units either optimize or find an overall Pareto optimum under the influence of the second level, which passes a vector of parameters into their constraint functions. This may be thought of as allocations of multiple resources to them. These resources are limited, and the second level objective depends on the allocations and on the decisions of first level units. There may be a third level which influences the second in a similar way. The model is an abstraction of many decentralized decision-making situations, and strategies for the various levels are discussed.

Other work (Professor Tone) deals with Benders decomposition algorithm, complementarity problems, and energy modeling. The work on Benders considers a parametric right hand side and extends the method to this case. Another application is to "pattern flow" problems, network flows in which the flows on certain arcs must satisfy constraints which render the overall problems not a network problem. Benders method is specialized to this situation. In complementarity, an algorithm is developed to solve linear complementarity problems with a more general set of coefficient matrices. This is applied to an interesting conflict situation, involving pollutors (who minimize costs, including taxes for pollution) and the public, which tries to minimize the pollution. The tax rates under which both reach the same solution appear as the solution of a linear complementarity problem. Professor Tone is also working on a large input/output model (500 sectors) of the Japanese economy, investigating the impact of reductions in imports of oil and of iron. He is also interested in food imports (Japan imports about 80% of its food) and has developed an LP model for this.

SOCIETY OF INSTRUMENT AND CONTROL ENGINEERS

The Japanese Society of Instrument and Control Engineers has about 7000 members. It includes many who are interested in automatic control and in systems and O.R. A group of about 20 members attended, both from industry and academia, and expressed interest in my talk on energy modeling and nonlinear optimization. I learned that Tokyo Gas Company has done many applications of modeling and optimization. These are described in the proceedings of the 1975 IFAC symposium.

I spoke later in the evening with a computer salesman from Toshiba Electric. They have sold an air conditioning plant to Russia, along with a microprocessor-based computer control system for it. The company has developed three-level hierarchical computer control systems, with microprocessors at the lowest level, doing direct process control, and micros, minis, or larger machines at the second and third levels, doing logging, sending signals to lower levels, and doing higher level control functions, e.g., production scheduling and inventory control.

INSTITUTE OF INFORMATION TECHNOLOGY (IIT)

IIT is a non-profit organization, with a small government subsidy, which gives courses of various lengths on information and systems topics. A group of about 35 attended my all-day lecture, about evenly split between academics and industry. A short informal discussion involving about 10 participants followed. A few

people had coded and tested some nonlinear optimization codes, including penalty and multiplier methods, gradient projection, and GRG. Some were users of LP codes, e.g., MPSX-370 of IBM. Two representatives of one company had coded and tested some special purpose large scale LP methods–generalized GUB for block-angular problems, and its specialization to multicommodity flow problems. The performance of the former was only fair, but the latter was much faster than a commercial general purpose LP code. Results were reported in a Japanese O.R. Journal.

GENERAL COMMENTS ON THE STRUCTURE OF ACADEMIC LIFE IN JAPAN

Faculty organization and procedures in most Japanese Universities are similar to those in Europe. There are a small number of chaired positions, occupied by full professors. A chair is associated with a specific field, e.g., systems theory. One associate professor and three assistant professors work under the chaired person. Promotion is determined partly by accomplishment (mainly publication), but also strongly by age. Hence a bright young person may have to wait a long time before reaching a chaired position. Salary is completely determined by rank and age. One can achieve tenure at the lowest level, and there is little movement of faculty from one institution to another.

The above system prevails at most public universities (Tsukuba is an exception), and also at many private ones. Waseda University, which is private, does not have the chaired system, operating in this respect more like an American university. Public universities have no sabbatical system, although some private ones (e.g., Keio) do. Faculty at public universities are government employees, not employees of the institution.

In contrast to the United States, Japanese universities are heavily inbred. In private universities (e.g., Keio and Waseda), about 90% of the faculty at a university have received at least one degree from that university. In public universities this percentage is more like 60%, but the largest public university, Tokyo University, is closer to 90%. Of course, one should note that some faculty may have received graduate degrees elsewhere, perhaps from a university in the United States, before returning to their alma mater. Although the author is no expert on Japanese (or anyone's) social customs, this inbreeding is certainly in harmony with the Japanese concept of life-long service to an institution. It also may be ascribed to the manner in which universities prefer to hire new faculty, more by a system of personal contacts than by the open interview process which dominates United States hiring practices.

INSTITUTE OF ELECTRICAL ENGINEERS OF JAPAN–(IEEJ)

There is some use of optimization among Japanese utilities. They have used non-linear programming to solve a variety of problems centering around generation and distribution of power through the network of transmission lines. One objective function used was minimum cost of generation to meet a given demand. In experiments at Tokyo Electric, the savings so achieved have been quite small and were judged not worth the effort. However, solution of problems dealing with system security has yielded better results. These are contingency planning exercises, in which certain faults are postulated in the distribution network, or certain generator outages are assumed, and the objective is to reallocate the remaining generation to minimize the amount of load that must be shed. There are also constraints on currents and voltages within the network. Such problems are very tightly constrained, and formal optimization methods do a good job of finding feasible, or nearly feasible, solutions.

There is increasing use of microprocessors in Japanese utilities. They replace analogue controllers, permitting more sophisticated functions to be performed at rapidly decreasing cost. Typical uses include the monitoring of currents and voltages, checking if they are within acceptable limits. An application still being developed involves the application of Walsh transforms (used because they are faster than the fast Fourier transform) to transform the ratio of voltage to current, yielding line impedance. This will be used to check for the presence of faults in the transmission lines, indicated by impedance changes.

GENERAL USE OF CONSULTANTS BY JAPANESE INDUSTRY

Consultants are less used by Japanese industry than by those in the United States. I was told that they are not accustomed to paying for the often intangible benefits (i.e., special expertise) that a consultant can provide. Also, there is some distrust or negative feelings against academics by industry, due to an "ivory tower" image of academia (which is partly supported by fact). In addition, consulting is discouraged by many administrators, because it creates conflict with leftist faculty and students, who oppose aid to big business and military establishments.

As a consequence, consulting activity occurs at a lower level for Japanese faculty than for their United States counterparts. For those who do consult, a popular mode is as advisor to a company, where a retainer is paid for the right to use up to a certain amount of the professor's time. Many faculty also give short courses in companies through private organizations which provide these educational services. In addition, Japanese faculty do some cooperative industrial research through industrial grants to universities. Problems studied in such research are often quite general, and results of immediate applicability may not be obtained. In general, there is a significant difference in problems solved by industry, which is very pragmatic and results oriented, and by universities, who prefer more traditional scholarly pursuits.

TOSHIBA ELECTRIC COMPANY–FUCHU WORKS

Toshiba is the second largest electrical equipment manufacturer in Japan (Hitachi is first) and approximately its 10th largest company. The Fuchu works employs several thousand and produces mainly control equipment, including microprocessors. Although there are many engineers doing design work, there are few (if any) applications of optimization methods in design. There is interest in exploring such applications. Another possibility is the use of optimization in software used for control, as the preparation of software for micro and minicomputers is one of the tasks at Fuchu works. Currently, there are few such uses of optimization.

One intriguing future application of optimization is to the water distribution system of the City of Tokyo. As described to me by Dr. Matsumoto of Toshiba, this would involve modeling the system, consisting of water storage tanks, supply sources, pipes, and consumption points. An aggregated model would involve about 80 nodes, and system simulation would require the solution of that number of (sparse) nonlinear equations. There are a number of possible objectives, including minimal pump power to satisfy demands, and minimal variation in the levels of storage tanks. The project is currently delayed due to the troubled financial condition of the Tokyo municipality.

YOKOHAMA NATIONAL UNIVERSITY

O.R. and systems work is done in a number of departments at Yokohama National University, including Electrical and Mechanical Engineering, Information Science, and Business Administration. There is interest in decomposition methods for optimization. One question was about how to overcome inaccurate solution of the subproblems in a two level Lagrangian decomposition algorithm, indicating that the questioner (a student) had done some computational experiments. Those researchers who had significant interest in mathematical programming had done little or no computing, concentrating on the mathematics of optimization. This appears to be a general tendency, probably arising from the strong distinction between "academic" and "applied" work in Japan. In particular, few researchers are interested in the development of optimization software, while there is strong and rapidly growing interest in this in the United States. Some Japanese have suggested that this is due partially to a lack of funds, which are required to support extensive computing. Money for academic research is not as plentiful in Japan as in the United States. In addition, most Japanese departments have a heavy undergraduate teaching load, which diminishes faculty research time.

HITACHI SYSTEMS DEVELOPMENT LABORATORY

The Systems Development Laboratory of Hitachi, Ltd., employs about 200 people, engaged in a variety of systems engineering tasks, mainly for clients, often in support of computers sold by Hitachi. Much of the work has to do with software preparation, often for control.

One project focuses on the Tokyo water distribution system. One of the models represents the pressures and flows in the system from the treatment plants to the water storage tanks. The variation of flow with pressure follows a nonlinear power expression. The objectives may be minimal pumping cost or, more likely, minimum leakage (which increases with pressure). The problem is dynamic (24 one-hour periods), but each period involves about 200 equations and variables, so each period has been solved separately by LP (the power law is linearized). Results are plotted and discussed with Tokyo officials, who may suggest new constraints or other model revisions. The ultimate concern is the ability of the system to meet future demands, and where expansion should occur.

Hitachi has solved this problem with their LP, a modification of IBM's MPSX which runs on Hitachi computers. The Japanese oil companies are extensive users of this system, and there is some use by other companies. These others are far less sophisticated, and often call on Laboratory personnel for technical assistance. Hitachi also has the SUMT NLP code, as well as an in-house version of PARTAN. This has been used to solve some problems in the design of controllers for industrial (e.g., steel) processes, to yield an "optimal" time response subject to constraints on control and state variables. These constraints were incorporated by penalty functions. This optimization routine, especially constructed for controller design, is rarely used now, due (reportedly) to the high run costs (and perhaps unfamiliarity of users).

Another problem has to do with selecting that subset of customer orders which meets constraints on the availability of certain equipment and which maximizes net profit. This is formulated as a 0-1 integer program of the capital budgeting type, with about 100 variables and 384 constraints. The Senju-Toyoda heuristic is used for solution. Another stems from a gasoline blending situation, where at most k of n raw materials can be used to blend a number of products, due to the fact that only k pipelines are available to convey the inputs. In addition, material properties (e.g., sulfur content) vary during the blending. Since the precise variation is not known prior to blending, and the decision as to which k raw materials to use must be made then, this problem is modeled as a stochastic program with the combinatorial constraint that at most k of the raw material variables can be positive. A branch and bound procedure is developed. Details are contained in reference (2).

TSUKUBA UNIVERSITY

Tsukuba University (a national university) operates differently, in many ways, than other Japanese universities. It has abolished the system of powerful chaired professors, has introduced a number of new curricula, e.g., social engineering, and management and policy sciences and is stressing continuing education, exchange programs with other universities, and faculty involvement in government and private research. It is located in a quiet country area about 40 miles northwest of Tokyo. There are plans to build about 40 government research institutes nearby. The university currently has about 3000 students and 600 faculty, and is constructing many new buildings. Plans are for a student body, graduate and undergraduate, of about 9,000 students.

One of Tsukuba's promising new (starting April 1976) programs is the Masters degree in Management Science and Public Policy Studies. A two-year program, it focuses on OR/MS areas such as economic modeling, simulation, statistics, information systems, and organization theory, which have proved useful in public systems work. In addition, there is study of various problem classes, categorized by level (federal, local, public corporations) and by sector (energy and natural resources, health, science and technology, environmental, etc). The program's purpose is to educate managers for positions in the public sector and to stimulate research on public policy problems.

An interesting project, initiated over four years ago by Professor Kuratani, is the construction of an interactive computer system to aid in personal financial planning. It is currently provided free of charge by a Tokyo bank to all who wish to use it, although only at one location, through a single terminal. The system input is data on a family's current assets, expenditures, income and investments, and future needs. Expenditures are compared with national averages, and significant differences are noted in the output. Future needs are compared to future assets and income, shortfalls are noted, and appropriate corrective action is suggested.

Professor Kuratani also worked for Hitachi Electric Company to design a planning and information system to aid in managing their extensive efforts in software development. The system contains data on each software

project, including man-hour requirements for various classes of programmers, desired completion dates, current status, etc. Requirements are compared to programmer availabilities, current status to desired status, and appropriate reports generated. The system was described as being essential to efficient operation of the software development groups.

There is extensive interest at Tsukuba in applying management science/OR to "soft" problems, including urban and social planning, energy and environment, etc. There was interest in the models for educational planning developed at Stanford and at NCHEMS in Boulder, Colorado. This stems partly from the need to justify the large sums being spent on this rapidly developing institution. Interest was expressed in the measurement and valuation of educational outcomes.

KYOTO UNIVERSITY

The Department of Applied Mathematics and Physics of Kyoto University has about seven faculty and 80 students, including 20 graduate students. A few of these are Ph.D. students. Some O.R. work is done there, in reliability, optimal control, and mathematical programming. In integer programming, Professor Ibaraki is working with heuristics and is trying to develop some theory dealing with relative merits of various branch and bound strategies. He has also done some simulations, generating the bounds randomly, and investigating options like depth-first versus breadth-first tree search strategies. Drs. Fukushima and Mine are interested in nonlinear and dynamic programming. In reference (3), they consider problems in which the objective and constraint functions are formed sequentially as compositions of functions of fewer variables, these being representable by a tree structure. If all the functions involved are monotone, it is shown that dynamic programming can be used to decompose the problem into a sequence of simpler ones, one for each level of the tree structure, dealing only with the new variable(s) introduced at that level.

Other work (4) deals with penalty methods and convex programs. In an attempt to avoid the ill-conditioning of penalty methods, the authors use the (Fenchel) conjugate of the penalty function. They prove that, under reasonably mild assumptions, the sequence of conjugate problems so formed leads to a constrained optimum, at the same rate as the penalty method itself. A limitation of the approach is the need to compute conjugate functions, which can be done in closed form only in special cases.

As in all other Japanese universities, there is little interest in the design of optimization software. This is probably true of software in other O.R. areas as well. There is also little use of software by students. Occasionally a small experimental code may be written to test an algorithm, but extensive testing and comparison seem rare. There is some interest in the implementation of algorithms, as well as understanding of the basic principles underlying algorithms, so perhaps this situation will change. As it is, emphasis is mainly on the mathematical properties of algorithms, on the use of optimization theory to obtain properties of optimal solutions to various models, and on various kinds of decomposition schemes.

A good current reference on Japanese O.R. is "Operations Research in Japan," a 16-page booklet published by the O. R. Society of Japan in 1975. Edited by Koichi Miyasawa of the University of Tokyo, it was distributed at the 1975 IFORS and ORSA/IMS meetings in Japan. For copies, write to the O. R. Society of Japan, Gakkai-Center Building, 2-4-16 Yayoyi, Bunkyo-ku, Tokyo 113, Japan.

TAIWAN

ACADEMIA SINICA–INSTITUTE OF MATHEMATICS

Academia Sinica is the Research Institution of the Republic of China. Its main mission is to do basic scientific research, which it conducts in 11 institutes. It had 243 researchers in 1974.

The Institute of Mathematics, directed by Dr. Fon-Che Liu, does research in many areas of pure and applied mathematics. It has three divisions–pure mathematics, statistics, and computer science. It has two minicomputers, PDP 8's with auxiliary disk and tape units, plus access to larger IBM 370 models at the National

Computer Center. It has an excellent library, with 9,000 volumes of mathematics books, and a good sampling of journals from many countries.

There is no current work in this institute in the O. R. or systems areas. There is interest in such work, of an applied nature, and interest in the possibility of setting up an O. R. section of the institute. Obstacles include difficulties in organizing applied projects with private industry or government agencies. The use of modern information technology in such organizations is in its infancy, and the use of MS/OR is even further behind. Other problems include obtaining competent analysts; there is a "brain drain" with many researchers attracted by opportunities in the United States. There are also problems of low salaries and red tape owing to the fact that this is a government institution.

One interesting project, already completed, focused on input/output systems for computers that would accept Chinese characters, i.e., getting computers to "understand" and "speak" Chinese. The complexity of the Chinese language, with over 10,000 commonly used characters, poses formidable problems. A smaller subset of these (perhaps 4,000) might be adequate for computer use.

A variety of approaches were investigated. Some of these involved trying to divide the characters of interest into smaller "elementary" characters, which would be composed to yield, uniquely, any desired character. But elementary characters which compose easily are very numerous, while those which are few in number (i.e., individual pen strokes) compose in a complicated way. The final system must be simple, and the software implementation should not be too slow. A number of promising approaches were developed, but much more remains to be done.

NATIONAL TELECOMMUNICATIONS LABORATORIES

These are the "Bell Telephone Labs" of Taiwan, the research arm of the Ministry of Telecommunications. The Director, Dr. Ting Ho, supervises a wide spectrum of research. There is extensive research into integrated circuit technology, with a great deal of sophisticated equipment for manufacturing IC's. This is in its early stages. Optical communications are also of much interest. I saw an experimental TV setup, with the picture transmitted from camera to screen by fiber optics techniques.

There are a number of interesting projects in the computer/O.R. area. A computer system for use by information phone operators has been designed and is being pilot tested. The existing system is for the operators to use phone directories. To implement computerized look-up, a system of phonetic Chinese characters (not part of the normal alphabet) has been devised, which fits exactly on a conventional Latin-symbol keyboard. Operators are trained to key in Chinese persons names (which contain three or less characters) in terms of these symbols. All names satisfying this input are displayed on a CRT screen, with addresses and numbers, in conventional characters. There are usually a few names at most, and operator and caller can easily select the correct one. The system has reduced total look-up time by a factor of 3, and is well accepted by operators. This constitutes a successful solution, in a special application, to the problem of Chinese I/O mentioned earlier.

Another problem is the location of central telephone exchanges in various cities, together with the assignment of phone users to these exchanges. This is a problem very similar to warehouse location, with the line costs from a user to the exchange known functions of distance, and fixed costs for setting up exchanges. Each exchange has a known capacity, and a forecast of distribution of users is also given, with a city divided into about 2,000 (or more) squares, and the forecast giving the predicted number of users in each square.

As stated, this could be formulated and solved as a mixed integer linear program. However, an additional problem feature exists, which is that all exchanges must be connected, and the cost of connecting any pair depends on the total number of subscribers assigned to both. For connecting new exchanges, this requires the introduction of a quadratic term (in 0-1 variables) into the objective.

The problem has actually been solved by applying a heuristic, which first fixes exchange locations, assigns customers to exchanges by sequential assignment of customers to the cheapest exchange not at capacity,

then searches for better locations (treated as continuous variables with x-y coordinates) by an exhaustive search over neighboring squares (with fixed assignments). This is repeated until the improvement in total cost is less than one percent. The entire process is repeated for various numbers of new exchanges, and the optimal number is selected. Satisfactory results have been obtained for a number of cities. One solution involves a demand forecast for 1996 for Taipei, and shows that 18 new exchanges (21 exist now) are needed, giving their locations and the assignment of users.

NATIONAL TAIWAN UNIVERSITY

This is the largest university in Taiwan, with 11,000 students. The department of mathematics gives bachelors, masters, and Ph.D. degrees, and teaches a few O.R. courses. There is a one year introductory O.R. course and a nonlinear programming course. While little or no research in O.R. is conducted, there is interest in such work. Faculty members are interested in starting applied projects, but are unsure as to how to go about it. Most are highly trained in mathematics, but quite unfamiliar with O.R. and systems methods and concepts. A number of faculty wanted recommendations for reading material in O.R., and some wanted O.R. curricula and course descriptions. The government of Taiwan is encouraging applied work in mathematics, but lack of trained personnel, and organizational constraints are hindering its initiation.

NATIONAL TSING HUA UNIVERSITY

This is a small university (about 1,500 students), quite prestigious, with about 200 graduate students. The Institute of Applied Mathematics, directed by Professor Lee, has about eight faculty and gives only graduate degrees. Until a few years ago, it was devoted to classical mechanics. Now it has three groups, computer science, probability and statistics, and classical mechanics. Courses in optimization and in basic O.R. are given by the computer science group, along with simulation and information systems. Professor Lee is seeking an applied orientation for these programs, including starting internship programs and project work with industry and government, and short courses and lectures in MS/OR and computer science applications for managers. These activities are new to Taiwan, and the management in industry and government is not yet as sophisticated as in the United States, so there is some uncertainty as to how to proceed. There is also a shortage of faculty. However, new faculty are being recruited and liaisons established. A new group, "Computer-Oriented Decision Sciences," will be formed to house some of these activities. This is likely to be one of the focal points for the dissemination of OR/MS and computer technology in the future.

HONG KONG

Education in Hong Kong is based on a British system. There are six years of primary and five years of secondary school. For those who wish to enter a university, two more years of secondary school are required. This provides one year of pre-university education more than the American system does. Hence university education requires three years rather than four.

Hong Kong has two major universities–Hong Kong University (HKU) and the Chinese University (CU) of Hong Kong. HKU is built on the hills of Hong Kong Island (it has a beautiful harbor view) while CU is on the mainland in the new territories in a country setting about 1/2-hour drive from downtown Kowloon. Both have about 4,500 students, mostly undergraduates. Only a small percentage of undergraduates go on to graduate school. Classes at HKU are taught in English, those at CU in Chinese.

Hong Kong Polytechnic (HKP) is different from these. It is not a university and is more oriented to technical training. Its role is analogous to that of our two-year junior colleges, but HKP's programs are more oriented to immediate application than are those of the universities. Students enter HKP after only five years of secondary school, rather than seven as required by the universities.

CHINESE UNIVERSITY OF HONG KONG

The Department of Mathematics at CU has about 18 faculty. It is mainly oriented to undergraduates, but also gives graduate degrees. Its faculty do no research in O.R. and teach no O.R. courses, although one

young faculty member works in control theory and is interested in mathematical programming. Some basic O.R. courses are taught elsewhere in CU, in computer science or in management studies. There is interest in O.R. coincident with plans to increase the emphasis of applied mathematics. However, the management school has pretty much pre-empted O.R. and will be its major future developer. Mathematics will play more of a service role for other departments, a prospect which appears bleak to many faculty.

HONG KONG UNIVERSITY

The Mathematics Department at HKU has about 13 faculty. Like CU, its primary concern is with the undergraduate program. There is no current research in O.R., but two one-year undergraduate O.R. courses are currently offered, one in basic O.R. (mostly LP) and one in queueing. There are supporting courses in probability and stochastic processes. There are no graduate O.R. courses—in fact, there are no graduate courses at all. Graduate students work directly with two advisors, and do readings and research work prescribed by them.

Students in the LP course have used an LP package, one written for the British ICL computer and limited to about 100 rows. The university also has software for PERT and for discrete event simulation. A few terminals are available for interactive computing.

The lack of development of O.R. programs within mathematics in both CU and HKU is due in part to two factors. Other departments have moved into O.R. faster, and many mathematics students enter jobs teaching secondary school upon graduation. The rapid growth of population in Hong Kong has generated a large demand for such teachers and for these a more classical education in mathematics is sufficient. Some faculty see this situation as eventually changing—they are aware of how fast the United States market for teachers dried up. For this and other reasons there is increased interest in applied mathematics, both at CU and HKU. The program in applied mathematics at HKU includes courses in computer science, statistics, and O.R. There are plans to add more O.R. courses, probably in mathematical programming, to the two mentioned earlier. A number of mathematics faculty are interested in O.R., but are unfamiliar with it. Some wish to develop research interests in O.R., others to organize student projects. These faculty are interested in O.R. education and practice in the United States.

At HKU, the Departments of Industrial Engineering, Statistics, and Management Studies also teach some O.R. Management Studies is a new department, just developing its programs. Industrial Engineering has developed a preliminary proposal for a masters program in O.R. It would be taken by persons currently working in HK, who would go 1.5 days per week for two years. The programs' aim is to produce O.R. practitioners, with emphasis on operations management (i.e., production management and inventory control). The proposed program is modeled after the one in the University of Birmingham in England, from which a number of Industrial Engineering faculty have come.

The Industrial Engineering undergraduate program also contains courses in production management, basic O.R., and simulation. The Industrial Engineering Department is fairly new, has eight faculty, and has about 100 undergraduate and 30 graduate students.

During my discussions, I heard of some British O.R. texts and related material which were new to me. Professor N.A.J. Hastings has written a Dynamic Programming software package, with an associated manual and textbook. He is in the Department of Management Studies at the University of Bradford, England. Also, there is a series of "Teaching Yourself" books, published in England, that includes "Teach Yourself O.R.," suitable for persons with a modest mathematical background.

HONG KONG POLYTECHNIC

Hong Kong Polytechnic is growing rapidly, and O.R. and related areas (e.g., statistics, computers, and mathematics) will play an increasing role in its future. It is not at all research oriented, but faculty from mathematics, industrial engineering, and management are interested in O.R., and some basic O.R. courses are taught in these departments. Faculty from industrial engineering are interested mostly in applications to production,

and some are familiar with basic mathematical programming. This latter statement applies also to a few faculty from electrical engineering and mathematics. Some faculty expressed interest in O.R. work in educational planning, and they hope to initiate some projects (perhaps carried out by teams of students and faculty) in this area.

PHILIPPINES

UNIVERSITY OF THE PHILIPPINES (UP)

The University of The Philippines is the largest university in the country, with campuses throughout the islands. The Philippine Center for Advanced Studies (PCAS) is solely for research and has about 35 faculty. Most of the quantitative work goes on in its institute for strategic studies. There is interest in energy modeling—the Philippines imports almost all its oil and has little other energy resources. A government energy board was formed in May of 1976. A project on developing a model for forecasting energy demand has been started at PCAS. It will last one year, and involve three senior and two junior staff. Forecasts will be by economic sectors. The data gathering phase, including imports, sector consumption, energy production, etc., has just ended. The project has encountered problems in obtaining data (particularly from oil companies) and in constructing an effective interface with government energy planners. Some earlier studies, done at PCAS and elsewhere, ended up gathering dust on someone's shelf, and the staff wishes to avoid this in the future.

ATENEO DE MANILA UNIVERSITY

Ateneo is a small, high quality Jesuit university, near the main UP campus about 10 miles from central Manila. The Mathematics Department, led by Father J. F. Nebres, gives undergraduate degrees, has a small masters and a very small, very new Ph.D. program, and has a large MS program oriented to upgrading the mathematics of primary and secondary school teachers. Ateneo also has a five year undergraduate program in management engineering, whose largest component is mathematics, but which also includes business and management courses as well as science and humanities. Students in this program take three semesters of O.R., a one year basic course plus a one semester course in LP. These courses are electives for mathematics majors.

Members of the Ateneo faculty have a heavy teaching load (four three-hour courses per semester with no assistance in grading). This, plus administrative duties, leaves little time for research. However there is an interest among some faculty in doing cooperative work with local industry and government agencies. One faculty member in mathematics (who teaches the O.R. courses) is starting a project with Manila Electric Company on problems of how much "spinning reserve" (generation capacity that is idle but can be placed into operation very quickly) should be present, and how the load should be allocated between the various generators. This appears to be the problem of trading off the risk of being unable to meet unexpected demands against the cost of maintaining the spinning reserve.

MANILA ELECTRIC COMPANY (MECO)

MECO is a large (quasi) privately owned utility, which has a large computer (IBM 370/145), a large computer and information systems staff to operate it, and an O.R. group of five or six people. Its computing power is among the largest in Manila, and it sells computer services to others, including Ateneo and the University of the Philippines. They have a large software library, including the SPSS and BMD statistical packages, GPSS for simulation, and MPSX/370 (with MIP option) for LP.

A few other companies in Manila also have O.R. staffs. The oil companies (mostly subsidiaries of foreign concerns) do a considerable amount of LP work, mostly in-house. IBM did some internal testing of an MIP model, and the San Miguel Corporation (which makes an excellent beer) has a small O.R. staff and reportedly has used LP for distribution studies. Philippine Airlines also has some O.R. capability. Smaller companies generally have little or no O.R. expertise. The computer revolution, with minis and micros, is evidently just starting here, so the basis for such work is largely absent. Similar comments apply to government agencies. I heard many complaints about unavailability of data, sometimes resulting from bureaucratic red tape.

One problem which has been modeled by MECO involves combining the operations of the National Power Corporation (NPC), which produces mainly hydropower, and MICO, which is thermal. The problem is basically one of allocating limited hydropower, by hour over 24 hours, plus the necessary thermal power, to meet forecast demands plus losses at minimal cost. A gradient method was used for solution. Implementation has been hampered by problems in obtaining data on the hydro operation. A problem of high priority in the future is that of the optimal level and allocation of spinning reserve mentioned earlier. Fuel costs are about 80% of generation costs today, and any reduction in fuel usage is eagerly sought. Related problems include optimal operation of the transmission and generation system to meet given demands. These have not yet been attacked.

An interesting public service program has been instituted at Ateneo. Students and faculty spend weekends and parts of summers in the countryside helping poor farmers with various projects. There is a supervisory organization which finds projects, organizes teams, and solicits funds, mostly from alumni. The program is quite new, but about 200 students (10% of the total) are involved, and the president of Ateneo said this work really "turned them on." It also directs research efforts toward the country's real needs, e.g., chemistry is now working on some local problems of extensive growth of water lilies in lakes. American youth claim to be anxious to do similar work. It is probably worthwhile to consider how such programs could be adapted to conditions in the United States.

SINGAPORE

SEMINAR ON OPERATIONAL RESEARCH IN DECISION MAKING
(July 12-15, 1976)

This two day seminar was organized by the Operational Research Society of Singapore and the Institute of Mathematics and Computer Science at Nanyang University. It attracted 78 persons, mostly from universities in Singapore and in neighboring countries, but a significant proportion were from government and local industry. There were three invited speakers—Professor Alan Mercer of the University of Lancaster in the United Kingdom (three lectures on marketing), Professor Rene Thom of France (one talk on "Catastrophe Theory in the Calculus of Variations"), and myself (two lectures, one on energy modeling, one on nonlinear programming). Each of these was one hour long. In addition, there were a number of shorter talks by faculty from the Universities of Hong Kong and Malaya, Nanyang University, the Singapore Public Utilities Board, the Port of Singapore Authority, etc.

The talk by the representative of the Public Utilities Board dealt with optimal allocation of load to currently spinning generators to minimize fuel costs, i.e., economic dispatch. There is a higher level problem, which is when to turn generators off and on in order to meet load plus and have an adequate spinning reserve. This is assumed to be known for the purpose of economic dispatch, which is done anew each half hour, with the results tabled and used directly. The economic dispatch problem is greatly simplified if transmission losses can be neglected. This can be done with little error in Singapore, where the longest line is about 25 km, so the solution is the classical one of equal incremental slopes. This must be modified slightly to account for upper and lower bounds on the allowable real power generation, and for a constraint on the total generation which can be transmitted from one district to another, due to the limited capacity of the lines. The solution has been implemented (recently) and savings in fuel cost were quoted as $2000 per day. Future plans involve implementation of similar solutions on-line, using small computers, recomputed at five second intervals as load varies.

Some other interesting problems were described to me by an engineer working with a small engineering consulting firm. They design a variety of networks in buildings, e.g., electric, gas, air conditioning, and water. In each case certain demands must be met at certain points, there are certain supplies of the fluid being transmitted, and discrete sizes of conductor (pipes, cables, etc.) are available. The problem is to choose the routing and sizing of the conductor from sources to sinks to meet demands and satisfy certain other constraints (allowable voltage or noise levels) at minimal cost. They had coded their own mixed integer programming algorithm and used it but now use mostly simplified algorithms based on certain network approximations. These can easily be used by an engineer with a programmable computer, and produce good results in a short time. They also allow for the engineers' intervention at any stage of the calculations. The engineer I spoke to received his

training in England, and commented that he was part of the first generation of engineers trained abroad to use modern methods who have returned to Singapore. They face a generation gap with the older engineers, who are usually their bosses or clients. Since Singapore only declared independence in 1965, its educational system is quite new (the oldest university, Singapore University, is 10 years old). Many vestiges of the old British colonial system remain.

Singapore Airlines also has a small (four or five people) O.R. group. It is less than a year old and is considering work on cabin crew scheduling. SCICON, the British computer services company headed by Martin Beale, also has a small branch here. It is planning to close, however, due to the small market and relative lack of management sophistication.

Dr. K. H. Phua of Nanyang University is one of the few persons I met doing research in mathematical programming algorithms and software. He is a student of D. F. Shanno and has published a number of papers in unconstrained minimization. His talk at the conference was on "Effective Comparison of Unconstrained Minimization Techniques." This work is described in a paper by that title which appeared in *Management Science*, November 1975.

NANYANG UNIVERSITY

One of the sponsors of the O.R. Conference, this university has about 5,000 students. The mathematics department is devoted mainly to undergraduate education, but gives masters and an occasional Ph.D. degree. It teaches four or five undergraduate O.R. courses, covering the major areas of O.R. It has a small computer, used mainly for educational purposes.

THE SINGAPORE OPERATIONAL RESEARCH SOCIETY

This society was formed in March 1976 and currently has about 70 members. The current president is Dr. Chew of the Nanyang Mathematics Department. Co-sponsoring the O.R. seminar was one of its first major activities.

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TWO TURBULENCE ORIENTED FLUID MECHANICS MEETINGS

Leslie S. G. Kovasznay

During the month of June 1976 two fluid mechanics meetings were held in the United States, in and around Washington, D. C. The first was the International Union of Theoretical and Applied Mechanics Symposium on Structure of Turbulence and Drag Reduction.

This was a IUTAM Specialists Meeting, sponsored primarily by the host organization with additional support from Air Force Office of Scientific Research, Office of Naval Research and David W. Taylor Naval Ship Research and Development Center. Attendance was by invitation only and there were 110 participants (69 from the United States and 41 from abroad). The symposium was devoted to the study of two related and slightly overlapping subjects. One was the detailed structure of turbulent shear flows and the other was the mechanism of drag reduction either by long chain polymer additives (Toms Effect) or by compliant walls. In the case of additives the working fluid is usually a very dilute solution of long chain polymers either in water or in hydrocarbon liquid, but similar effects have been observed in air flow with suspended dust or other small particles. The flow over compliant walls is a controversial subject and one full session was devoted to its discussion. The study of drag reduction in turbulent flows brings into focus the urgent need for understanding the dynamic structure of turbulence itself. Thus, these studies may actually contribute to a better understanding of the physical processes involved in turbulent transport of mass, momentum and heat. There were about 45 papers scheduled for a full week's program with adequate time for discussion.

Slightly more than half of the authors were from outside the United States. About one-third of the papers dealt with turbulent structures without any reference to the drag reduction problem. There were also some papers concerned solely with the behavior of high polymers in very dilute solutions and there was a substantial number of papers reporting results on the structure of turbulence in flows with drag reducing high polymer additives.

Various papers reinforced the suggestion that the observed drag reduction is due to an increase in the effective viscosity in the fully turbulent portion of the flow. Apparently the effective viscosity still remains small (near the Newtonian value of the solvent) within the viscous sublayer increasing gradually within the turbulent portion of the flow. Furthermore the viscous sublayer appears to thicken with increased additive, quite in agreement with the observed drag reduction. In this report our main concern is the contributions of authors from the Far East and the Pacific area so we shall briefly review only those papers.

"Effect of Elongational Viscosity of Polymer Solution on Taylor-Görtler Vortices" by Y. Tomita and T. Jotaki, Kyushu Institute of Technology, Kita-Kyushu, Japan. This theoretically oriented paper was presented at the Symposium by Professor Tomita. The paper aimed at examining the effect on drag reduction of certain types of flow instabilities that ultimately may lead to transition and turbulence. The authors calculated the Taylor-Görtler instabilities for the case of a dilute polymer solution. The principal physical assumption is that the fluid possesses an "elongational viscosity" that may be one or two orders of magnitude greater than the conventional Newtonian viscosity. The authors' calculation technique follows a method similar to that of Hämmerlin. The results indicate that boundary layer flows over a concave wall become unstable at a higher "Görtler-number" (nondimensionalized curvature) than for the solvent liquid alone. In addition the authors found that the spatial scale of the vortices increases with an additive. There are still no experimental results available on Taylor-Görtler instability in flows with drag reducing polymer solutions.

A particularly important paper from Japan was entitled "Reduction of Eddy Diffusivity for Momentum and Heat in Viscoelastic Fluid Flow in a Circular Tube" by T. Mizushina and H. Usui, Department of Chemical Engineering, Kyoto University, Kyoto. Professor Mizushina presented the paper reporting new experimental results obtained in his laboratory. Detailed measurements were given on a turbulent pipe flow; these included the mean velocity distribution and turbulence characteristics all measured by LDV (Laser Doppler Velocimeter). In addition to the mean velocity and the r.m.s. value of the streamwise velocity fluctuation, burst periods were measured. Furthermore the turbulent heat transfer properties were measured by using a number of thermocouples. The principal experimental findings may be summarized as follows:

1. The turbulence intensity was reduced in the wall region quite in accord with the drag reduction effect but the turbulence intensity in the central region of the pipe remained unaffected by the additive.

2. A universal turbulence intensity profile at the maximum drag reduction asymptote was found.

3. The average burst frequency observed at the wall was significantly lower with the drag reducing additive than with the Newtonian fluid.

4. The turbulent eddy diffusivity for heat was reduced near the wall just as the eddy diffusivity for momentum.

The authors indicated that a simple eddy diffusivity model can account for all the measurable effects, which is certainly useful for the prediction within engineering accuracy of transport properties in drag reducing flows. It may be added parenthetically that Professor Mizushina is an active leader in Japan in the research from a chemical engineering slant on turbulent flows. I visited his laboratory at Kyoto University and observed a large variety of interesting fluid mechanics projects. In addition to his professorship in the Department of Chemical Engineering, Professor Mizushina is currently serving a term as director of the Nuclear Energy Research Institute of Kyoto University.

Another prominent Japanese scientist attended the Symposium, although he did not present a paper. Professor I. Tani chaired a session and he was a member of the Scientific Committee that organized the meeting.

Three papers concerned with the structure of turbulent shear flows without the presence of any drag reducing agents were presented by Australian scientists.

"Free Stream Turbulence and Shear Effect on Boundary Layer and Wake Structures" by A. A. Ahmad, University of Sydney; R. E. Luxton, University of Adelaide; and R. A. Antonia, University of Newcastle, Australia. Professor Luxton presented the paper on work done at the University of Sydney when both he and Dr. Antonia were still there. (Recently they both moved to their new academic positions.) The central theme of the paper was the study of the effect of both the mean shear (mean velocity gradient) and the turbulent energy in the free stream on two different basic shear flow configurations. In the first case a cylinder was placed in a nearly homogeneous turbulent shear flow. (Professor Luxton has studied homogeneous turbulent shear flows in Sydney for many years.) In the wake behind the cylinder the effect of the mean shear and turbulent energy on the growth of the wake width and on the turbulent length scale in the wake appeared to be small, almost negligible; on the other hand, the external shear flow caused an asymmetry of the wake and a skewness in the orientation of the wake axis. In the second case, a flat plate was placed in the turbulent shear flow and the turbulent boundary layer growing along the plate was studied. In this case, there was some change varying according to whether the sign of the shear in the external flow was the same as or opposite to the sign of the shear in the boundary layer. But a much larger effect was attributed to the turbulence level of the external flow. The external turbulence appeared to affect strongly both the growth rate and the large scale structure in the turbulent boundary layer along the plate. An interesting conclusion was suggested by the authors, that the difference in response by the wake and by the boundary layer to external shear or turbulence may be due to the sensitivity of the mechanism by which large scale structures are generated in the boundary layer near the wall in contrast with free shear flows, such as the wake behind the cylinder, where the large eddies are created by a powerful inviscid type of instability after the flow has left the solid boundary of the cylinder.

"Temperature Dissipation Fluctuations in a Turbulent Boundary Layer," K. R. Sreenivasan, H. Q. Dahn and R. A. Antonia, University of Newcastle, N. S. W., Australia. Professor Antonia presented the paper whose subject is a classical problem, but using a new and rather refined experimental technique. An array of four hot-wire anemometers was used at a very low heating current, so that they acted effectively as resistance thermometers. They recorded the temperature fluctuations, and the four signals were combined in pairs to form the spatial derivatives of the temperature in order to calculate the fluctuations in the temperature dissipation. From one pair of wires one obtains T_y and from the other pair T_z while the third component, namely T_x, was obtained by first forming T_t by a differentiating circuit, then invoking Taylor's hypothesis to convert the time derivative into T_x the streamwise space derivative. Mean square values of all three quantities and spectral measurements indicated that in the inner region of the boundary layer the assumption of local isotropy in Kolmogorov's sense is not a good approximation. Furthermore the authors found that the streamwise component of the temperature gradient is richer in high frequency content than the other two components. The sum of the squares $T_x^2 + T_y^2 + T_z^2 \equiv K$ seemed to approximate the so-called "Log Normal Law" (proposed by Kolmogorov as a consequence of his third hypothesis (1961)) better than did any one of the three components alone. Indeed, the variance of the logarithm of the locally averaged K was found to be proportional to log r over a range of r's extending over a ratio of 1:30, although for the individual components the "Log Law" was valid only for a much smaller range, for a ratio of about 1:3. The "Kolmogorov-constant" of the "Log-Normal Law" was found to be 0.35. The most important consequence of the reported research is its warning to other researchers to use all three components of the gradient for calculating a dissipation function, because, if only one component is used, based on a hope for local isotropy, the results will be more erratic and could lead to serious error.

"Effects from the Large Structures in Mixing Layers and Further Evidence of the Structure of the Boundary Layer" by G. L. Brown, University of Adelaide, Australia. Dr. Gary Brown is well known in the United States mainly for his thesis work with Professor A. Roshko at the California Institute of Technology, Pasadena. At this meeting Dr. Brown reported experimental results obtained in his new facility at the University of Adelaide. His paper consisted of two parts. In one part he continued his earlier work studying the mixing layer between two parallel gas streams, but using his new facility. In this series of experiments he measured the effect of compressibility (Mach number) on the large scale structures detectible in the shear layer and he found the compressibility effect to be considerable. In the other part of his paper he reported a new experiment searching for large scale coherent structures inside the turbulent boundary layer. He used both wall shear probes and also an array of hot-wires. The most striking new finding was the high correlation (with no relative time delay) between the low-frequency component of the wall shear stress and the high-frequency shear fluctuation level. The convection velocity of the large scale structures was about 2/3 of the free stream velocity, a value somewhat different from the often quoted 80% value measured as the overall convection velocity of the wall pressure pattern in a turbulent boundary layer.

There was only one paper from India, but its senior author is quite well known in the United States, his work often quoted in the "drag reducing research" community.

"Triggered Transition in the Pipe Flow of Dilute Solution of Random Coiling Macromolecules" by P. S. Virk, M. Ohara, Indian Institute of Technology, Madras, India. In a carefully planned and rather extensive experimental program, laminar-turbulent flow transition was studied in circular pipes in which large upstream disturbances were created by a constricting orifice placed immediately before the entrance of the test section. The authors distinguished three types of transition as a function of additive concentration and type.

1. Laminar to Newtonian turbulent flow that occurs at concentrations where the polymer did not cause any drag reduction and all flow characteristics are indistinguishable from Newtonian flow.
2. At higher concentrations the flow exhibited drag reduction at the earliest fully turbulent state. The critical Reynolds number was found to be the same as in a Newtonian flow but a more distinct intermittency was observed at the pipe axis than for a Newtonian flow.
3. The maximum drag reduction case when the transition to turbulence did occur at a *lower* Reynolds number than in a Newtonian flow (Re = 1500 instead of Re = 2000), but no intermittency was discerned.

After the formal papers presenting new research results, there was a general discussion. The principal participants were prominent researchers such as C. Elata of Israel, M. T. Landahl from Sweden, and J. L. Lumley of the United States, all trying to come to a general consensus of interpretation.

There was a well attended banquet at which the speaker was Professor A. B. Toms of the University of Birmingham, England, the person for whom the "Toms Effect" has been named. Professor Toms gave pleasant reminiscences of the early history of the phenomenon to which the entire meeting was dedicated.

The other meeting attended was sponsored by Project Squid (ONR) and its title was "Workshop on Turbulence in Internal Flow" held at Airlie House (an old estate now transformed into a small convention center) in the Virginia countryside near Warrenton. The surroundings were very attractive.

The meeting was attended by approximately 75 invited participants and the advance program announced about 15 formal lectures. In addition, a number of shorter presentations were squeezed in later, resulting in a rather full schedule. Project Squid arranged the meeting to follow immediately the IUTAM Symposium in Washington so that many visitors from distant places were able to attend both. In fact, about a dozen participants were from abroad.

The theme of the meeting was unsteady interaction with solid bodies of turbulence or of large scale vorticity. The possible applications to rotating machinery were always kept in mind.

The only formal lecture coming from the Pacific area was:

"The Effects of an External Turbulent Shear Flow on a Turbulent Boundary Layer," by A. A. Ahmad, R. E. Luxton and R. A. Antonia, University of Newcastle, Australia, delivered by Professor Antonia. He gave a rather detailed account of the research aimed at determining the influence that both the turbulence and the mean shear in the free stream exercise on the development of a turbulent boundary layer. The research upon which the paper was based is essentially the same as for the one given in the corresponding paper at the IUTAM Symposium. However, at this meeting a full hour was available for the presentation instead of 20 minutes for this and another topic combined as at the IUTAM meeting. Consequently, the authors gave a great deal of the rich detail of their experimental results, some of which were quite surprising. It became clear that the free stream turbulence significantly alters the generation of the large scale motion believed to be initiated near the solid wall. In addition, the mean shear of the external flow alters the entrainment characteristics. It was surprising to find that the shear becomes zero near the edge of the boundary layer for *both* positive and negative external mean shear. This finding seems to be supported by the additional experimental results that both the mean velocity gradient and the turbulent shear stress (Reynolds stress) vanish at the same location.

The meeting had a relatively large French contingent indicating great interest in this type of research both in academic circles (Professor G. Comte-Bellot from Lyon and Dr. J. Gaviglio from Marseille) and also Government Laboratories of Office National D'Etudes et de Recherches Aerospatiales (Dr. M. L. Barrère and Dr. O. Leuchter).

In my opinion, the Director of Project Squid, Dr. S. N. B. Murthy of Purdue University, has done a creditable job in organizing such a fruitful and pleasant meeting, especially in attracting such high quality participants from outside the "Squid family" and even from overseas. This was achieved without any international organization participating in the sponsorship.

In addition to participating in the two meetings, I had a chance to discuss research problems with a number of well known fluid mechanicists of the Boston-Cambridge area. Professor F. Abernathy of Harvard described his yet unpublished work on the effect of a long chain polymer additive on a free vortex flow (the configuration is the well known "bathtub drain vortex" problem), that seems to confirm the findings of others obtained in other non-turbulent flows with drag reducing additives. Professor Sheila Widnall has returned to M.I.T. after a year at the Department of Transportation in Washington and has resumed her research on unsteady vortices.

Professor Eric Mollo-Christensen of M.I.T. has recovered from his earlier serious illness and is active again in studying fluid mechanics of the ocean. Professor J. L. Kerrebrock also of M.I.T. is trying to synthesize into a theoretical framework the experiments performed with the M.I.T. instrumented single-stage research compressor. He is concerned with an interesting problem, the merger of the individual vortices that are shed from each blade, a phenomenon that causes a change in the propagating acoustic modes in the ducting and profoundly influences the sound emission of jet engines.

APPLIED SCIENCE AT THE UNIVERSITY OF OSAKA

Leslie S. G. Kovasznay

The University of Osaka is a former Imperial University and traditionally it is rated by the Japanese either as the second, immediately after the University of Tokyo, or as the third, ranking after the University of Kyoto. As far as science and engineering is concerned, even a superficial look conveys a feeling of vigor and ambition. The University is spread over three major campuses. First, in Osaka proper is the Nakanoshima Campus that houses the central administration and the health sciences: Medical School, Dental School, etc.

Outside the city proper is the Toyonaka Campus located about 12 km due north from the center of Osaka, quite close to the Osaka International Airport, that serves the entire Osaka-Kyoto-Kobe area. The Faculty of Science and the Faculty of Engineering Science are both located at the Toyonaka Campus, and there seems to be sufficient land for further expansion.

Another Campus is located in Suita City farther out from Osaka, about 5 km northeast from Toyonaka. On the Suita Campus are located the Faculty of Engineering and a number of research institutes. In addition to those, there are many other divisions and special activities, but here we are concerned only with science and engineering. The division into faculties of Science, Engineering and Engineering Science appears to be quite arbitrary and it is due both to historical development and to administrative convenience. The geographical dispersion of the university does not appear to be as serious as one would suspect from the above description. One reason is that the campuses are rather autonomous and another is that interaction and cooperation among the groups is facilitated by the relative abundance of public transportation and highways. The entire Osaka-Kobe-Kyoto area is a highly populated, highly industrialized and well developed area with adequate commuting facilities for a combined population of about 10 million people.

The groups visited were chosen for their scientific reputation in the author's area of competence and for the availability of the key scientist at the time of the visit (in that order). First the Toyonaka Campus was visited beginning with the Faculty of Engineering Science. In the Department of Material Physics (Bussei Butsuri Kogakka), Professor F. E. Fujita is working on those aspects of solid state physics that seem to be directly relevant to metallurgy. In addition to the usual tools of crystallography (different varieties of X-ray diffraction techniques), Professor Fujita has adopted a new technique, Mössbauer spectroscopy, and he is now using it extensively. The Mössbauer spectroscopy is eminently suited to investigating ferrous alloys because the resonant absorption of the Fe^{57} isotope can be utilized using the readily available cobalt Co^{57} radiation source. The problems investigated by this method include, but are not restricted to, quenching and tempering of plain carbon steel, the study of Martensite phase and Martensite transformation, the magnetic properties of Invar, etc. Professor Fujita has a rather strong personal stand concerning the Martensite structure. He describes it as a six-layer stack with alternate "shuffling" between the face-centered and body-centered position of the carbon atom. He has shown a recent electromicrogram (still unpublished) that appears to support his proposed model and he expects to win the acceptance of his ideas concerning the Martensite structure at the forthcoming First J.I.M. International Symposium (JIMIS–I) to be held in Kobe, May 10-12, sponsored by the Japan Institute of Metals (Kinzoku Gakkai).

Clearly Professor Fujita is active in a large range of topics. He actively cooperates with the ultra-high voltage electron microscope laboratory (Suita Campus) investigating metallurgical damage to specimens by high power electron beam.

Within the same Department of Material Physics, Professor N. Kawai has built up a rather unique ultra-high pressure laboratory. The maximum pressures attained are claimed to be of the order of one MegaBar (about one million atmosphere). The method for creating such high pressures may be described as follows: The pressure vessel is loaded through several shells of varying geometrical configurations that serve to pass the linear compression by the two anvils into a small vessel squeezed by isotropic compression. The outer shell is spherical and it is split into six identical segments, and three of them are pressed by each of the two holders (anvils). Each one of the six segments has an inner square face forming a hollow cube. Into this cube-shaped hollow are placed the eight cubic compressor elements, separated from each other by thin sheet spacers. The eight cubes' inner corners meet at the very center of the configuration, and here is where the high pressure is attained. The compressor elements are made of tungsten carbide or sintered alumina. In some experiments the eight corners at the center are ground off so that they form an octahedral cavity. Into this hollow octahedral space is placed the test material. If the test object is a solid, it is formed into the shape of an octahedron (just slightly larger than the hollow space). The success of the whole method depends critically on high quality technology used to form (sinter and grind) the compressor elements.

The most interesting research results obtained so far are the conclusive measurement of electrical resistivity and Professor Kawai's claim to have established the metallic state both in water (H_2O) and in hydrogen (H_2) at pressures in the range from a few hundred KiloBar to one MegaBar. In a somewhat different configuration, a split-cone type of pressure vessel was used, leaving a small slit in the meridian plane (perpendicular to the original load axis) which allowed X-ray diffraction studies of the compression or phase change in the crystal lattices.

Also in the Faculty of Engineering Science, in the Department of Mechanical Engineering, Professor T. Murasaki directs a laboratory dealing with fluid mechanics and certain aspects of plasma physics. There is a great variety of flow facilities available: Shock tubes, vacuum tank with plasma jet, electrical discharge tubes for plasma experiments, also some low-speed flow facilities, wind tunnels and water tanks. It is clear that the laboratory is in the process of reorientation, just as many similar ones both in the United States and in Europe. The more classical type of plasma experiments are still being continued, such as the study of the structure of shock waves in partially ionized gases, but the new interest is centered on gasdynamic lasers. An electric arc heated CO_2 laser and a shock tube driven CO_2 gasdynamic laser are both studied by using fluid mechanical as well as optical instrumentation.

In low-speed flow, various special subjects are investigated. One example is vortex shedding from a constricting orifice placed in a duct.

The high ionization occurring behind a reflected shock wave is utilized in "crow-bar" devices developed by Professor Murasaki and his associates. "Crow-bars" are essentially very fast switches to short out the condensers in high energy plasma devices at the exact moment when oscillation passes through near zero voltage but has the maximum current (10-50 KA).

Still in the Faculty of Engineering Science, in the Department of Information Engineering headed by Professor K. Tanaka, research work is being carried out on a large variety of computer utilization projects. Among them, the most striking is the stereoscopic representation of the heart by the use of ultrasonic echo tomography. This project was directed by Professor Tanaka in collaboration with Professor Y. Abe of the School of Medicine, and together they have developed an operating prototype of a diagnostic device. In a typical configuration, ultrasonic pulses of 2.25 MHz are sent out by a concave transducer (30 mm diameter and 200 mm focal length) resulting in a spatial resolution of the order of 3 mm (cca 1/8") in the echo producing target. By mechanical scanning and preliminary filtering (spatial averaging) a 105 x 80 picture element echo-cardiogram is prepared where each picture element is represented by a 7 bit number on the intensity scale (gray scale). Usually about a total of ten such two-dimensional pictures (tomogram) are prepared, one for each section. Since the heart moves during the cardiac cycle, each picture is taken at the same phase of the cardial cycle by synchronizing the emitted ultrasonic pulses to the electrocardiogram. The large three-dimensional array of points so obtained is stored on a disc, and it is further processed by the computer. First the location of the solid boundaries is determined, essentially by a contour plotting algorithm, then the results are displayed for the diagnostician by using several display modes:

1. Contour lines displayed in one section, called a tomogram.

2. Contour lines displayed in any arbitrary plane section. The location and orientation of the plane are controlled by a "joy-stick." This convenience permits the diagnostician to "see" the particular cross section of the heart he wishes, so that he can follow the shapes of the cavities section by section in any orientation.

3. Stereoscopic display. From the stored three-dimensional data a pair of images are computed, one for the left and one for the right eye, so that when viewing through a stereo viewer, the heart cavities are seen in 3-D by the operator diagnostician.

Another large effort of the group is directed toward studying methods for the recognition of printed characters especially the Japanese KATAKANA characters. With the advent of automated business operations the Japanese business machines type names and addresses mostly by KATAKANA characters so in Japan the automatic reading of those is the most urgent need. There are about 50 KATAKANA characters, so the problem is comparable to that of reading Roman letters. On the other hand reading KANJI (Chinese characters) is a greater problem by more than an order of magnitude since there are 1850 officially designated TOYO KANJI's in use and most of them are considerably more complex than KATAKANA.

Next in the Faculty of Science, the Department of Physics was visited, where Professor M. Date created a Laboratory of Very High Magnetic Fields. Here continuous (D.C.) magnetic fields of the order of one Mega-Gauss (or more correctly one MegaOersted, but in air the numerical value is the same for H and B) are being produced by using a special design. Ordinarily the maximum magnetic field is limited by the tensile strength of the electric coil as the magnetic "pressure" (more correctly the Maxwell stress tensor) acts on the confining coils. The design principle of Professor Date's magnet is to create the high field along the axis by superposing a number of coaxial cylindrical coils each designed separately for its limiting value of the magnetic field. When these coils are all telescoped together the field strength on the axis will be superimposed, but each layer will carry separately its share of the magnetic pressure without exceeding the mechanical strength of the material. The outermost coil is designed for the mechanical limit, which for a beryllium-copper alloy coil is about H_0 = .5 Mega Oersted, and each subsequent coil is similarly designed, each floating freely without any mechanical contact among them. It can be shown theoretically that an N layer configuration so constructed results in a maximum field strength at the center,

$$H_{max} = H_0 \sum_{n=1}^{n} (1/n).$$

The reasoning reminds one of the calculation for the maximum velocity attainable by multistage rockets, where the velocity also increases without limit with the number of stages but at a cost of building increasingly larger and larger structures relative to size of the payload. Correspondingly in the multilayer electromagnet the useful volume for the specimen becomes smaller and smaller upon increasing the number of layers N. The principal use for such high magnetic fields is electron spin resonance (ESR) measurements in the millimeter wavelength region. What makes these measurements timely now is the availability of submillimeter sources, such as the H_2O laser with λ = 119 micron or the HCN laser with λ = 337 micron wavelength. Corresponding progress was made in the available detectors. Professor Date and his associates recently published their results on ESR in the $CuCl_2 + 2H_2O$ crystal (Jour. Phys. Soc. Jap. **39** p. 989, 1975).

In addition to ESR, results on a different type of problem were reported by Professor Date. In superfluid helium, vorticity (more exactly the circulation) is supposed to be a quantized variable. Date has shown that quantized vortices in Helium II exhibit a cross-over from charged vortex rings to ions (Jour. Phy. Soc. Jap. **39** p. 553, 1975).

The Suita City Campus was visited next. The Osaka University Super High Voltage Electron Microscope Center is housed in a separate building. The 3 million volt accelerating voltage electron microscope extends over several floors. For a while it had the world's highest accelerating voltage although recently a microscope

was constructed in France using 3.3 MV. The nominal ultimate resolution is ≈ 2 Ångström, a distance comparable to the atomic distances in crystal lattices. The voltage stability is better than 10^{-5} per minute. The recording system now includes a closed circuit television system but a special image processing system is being planned for the near future. Since the specimen is in hard vacuum, remotely controlled specimen treatment is incorporated such as cooling, heating, tilting and straining (loading) of the specimen under observation.

According to the Center's director, Professor H. Fujita (not to be confused with the previously mentioned F. E. Fujita), about 75% of the experiments are related to solid state especially to metallurgical research, and the other 25% are miscellaneous mainly biological. Using high accelerating voltage has as a chief advantage a much greater penetration than using lower voltages so that relatively thick specimens can be successfully observed. The maximum utilization thickness at 3 MV is about 15 times the value for 100 KV, so that bulk specimens can be observed in all metals, even in the heavy metals such as molybdenum, tungsten, gold and uranium. The possibility of using a rather thick specimen may offer some special advantages in biology too. It may make possible the use of a living specimen that will survive several exposures, in contrast to the usual very thin specimens that are dehydrated, carbonized, etc. Nevertheless this aspect of the use of high accelerating voltage has not been fully exploited.

The last laboratory visited was the Institute of Laser Engineering under the direction of Professor C. Yamanaka. Here there was a large effort to devise a controlled nuclear fusion experiment. The configuration chosen uses a rather strong laser pulse to heat a small deuterium bead. The laser system consists of an oscillator and a five-stage amplifier delivering a Q-switched pulse of nanosecond duration with a total energy of about 50 Joule. Presently two such laser systems are being built and they are focused onto a small diameter (a fraction of a millimeter) glass bubble containing the high pressure deuterium pellet. The reflected and scattered radiation is analyzed by a spectrometer and the collapse, heating and expansion of the pellet is followed by time resolved holography.

A seminar entitled Laser Interaction with Plasma was hosted by the Osaka Group. It was held at Mt. Fuji, November 7-9, 1975, with rather good international participation. The proceedings (186 pages) were published under the same title with Professor Yamanaka as editor.

In summary only the highlights of the activities of Osaka University were scanned during the brief two-day visit. The overall impression obtained was that there are active, vigorous and occasionally spectacular efforts in the applied science area.

THE KOREAN INSTITUTE OF SCIENCE AND TECHNOLOGY: OBSERVATIONS AFTER A BRIEF VISIT

J. W. Morris, Jr.

During a recent trip to the Far East in connection with ONR-sponsored research I had the opportunity to spend a few days as the guest of the Korean Institute of Science and Technology (KIST) in Seoul, Korea. While I hardly qualify as an expert on industrial development, KIST certainly appears to be a type of government-industry laboratory which can play a significant role in the technological advance of a developing nature. For this reason it seems worthwhile to bring the Institute to the attention of this readership.

KIST was founded in the mid 1960's as a joint venture by the Korean and U.S. governments. Its stated purpose was two-fold: to increase the rate of technology transfer to Korea and to provide innovative technology for Korean industry through specific research and development. The Institute was organized, roughly following the pattern of the Battelle Memorial Institute in the United States, as an independent, non-profit agency deriving its support through specific research contracts from industry and government. Since its founding in 1966, and the opening of its laboratories in 1969, KIST has grown to an organization with some 850 staff employees engaged in over 200 active contracts annually. Roughly 70% of its current income is derived from industrial contracts. The bulk of the remainder comes from the Korean government, again principally in the form of specific research contracts.

The Institute is situated in the Hongnung Science Park in the eastern section of Seoul on a 65-acre hillside site which has the peace and charm of a well-landscaped park within a very crowded city. The buildings, which were completed in 1969, are modern and attractive. They include large central laboratory buildings, a residential complex for senior staff, and attractive guest and conference facilities in outlying buildings. The offices are modern and the laboratories are spacious and functional. The whole impression of the Institute is that it is a very pleasant place in which to live and work.

The executive head of the Institute is its president, Dr. Sang Joon Hahn. He reports to a board of trustees which is principally Korean, though at least two Americans are included in its current membership. Dr. Hahn is assisted by three technical vice-presidents and a vice-president for administration. The technical vice-presidents direct the three technical subdivisions of the Institute, Research Group I, which includes agriculture, chemical engineering, organic chemistry, and industrial engineering, Group II, which includes electronics and mechanical engineering, and Group III, which includes metallurgy and metals-related fields. The Institute also operates a consulting office for foreign technology transfer, and is responsible for the Korean Research Institute for Ship and Ocean Engineering, a separate institute located on the sea coast.

The senior staff of KIST consists principally of individuals who received education to the Ph.D. or beyond in the United States or Europe. One of the principal arguments for establishing a research institute of this sort is the consequent opportunity for repatriating highly qualified engineers who have been educated abroad, hence achieving a direct technology transfer. In this area KIST appears to have been highly successful. The senior staff members whom I met in the metallurgy and mechanics areas impressed me as both competent and enthusiastic. The junior staff is principally Korean trained to the B.S. or M.S. level (a Ph.D. engineering program has only recently been established in Korea with the formation of the Korean Advanced Institute of Science, KAIS). I had very little direct contact with the junior staff during my visit. However, the senior staff with whom I spoke seemed generally satisfied with the quality of the Korean-trained engineers available to them, though they felt that there is a definite shortage of trained B.S. engineers to meet the simultaneous needs of Korean research and industry.

The metallurgical and mechanical laboratories which I visited at KIST seemed reasonably well equipped for general industrial support, and were in active use on a variety of projects. As may be anticipated, however, the laboratories did lack many of the more sophisticated pieces of equipment which a comparable American laboratory would regard as essential. They specifically lack a good universal testing machine for fatigue and fracture toughness testing and are short of advanced metallographic equipment for materials characterization and fractography. The senior staff in this area seemed fully aware of their equipment needs. However, modern apparatus for mechanical testing and analysis is expensive, and one can appreciate the conflicting claims on the limited capital budget of a growing laboratory in a developing country.

In keeping with its mission the work being done at KIST appeared to fall into three general categories. The first is new product and process development for industry. I was shown several examples of KIST-developed products now in production and work-ups of industrial processes which are now either in production or in the pilot plant stage. The second class of contract involves the identification and solution of problems in production or in the quality control of finished products. The third is quality control itself, where the specialized equipment and expertise at KIST is used to certify production output. While there is a small effort in long-term basic research, the principal product of KIST is short-term development of a highly applied sort, the work which would probably be assigned to internal engineering laboratories in an American company of reasonable size. KIST is hence effectively functioning as an adjunct engineering laboratory for Korean industry.

It is difficult to assess the contribution of KIST to Korean development on the basis of a brief visit. However, an organization of this type offers several potential advantages to the country which seem to be realized in practice at KIST. First, given the enormous cost of establishing, equipping, and staffing a modern engineering laboratory, there is an evident advantage to centralization, provided that the central laboratory can establish and maintain a good technical relationship with the industries it supports. In a country like Korea where capital is short and many important industries are either very small or very young centralization of laboratory facilities would appear to be the only economically feasible way to establish a modern, independent technical capability. Recognizing the economic problem a country may establish a government-funded central facility, but then faces the problem of interfacing its central engineering with its industrial needs. The Battelle model used at KIST, in which the central laboratory is supported principally through industrial contracts, offers a direct solution to the interface problem. The increasing level of industrial support at KIST suggests that the theoretical advantage of this organization is being achieved in practice.

Second, one of the principal needs of a developing nation is to identify and adapt appropriate modern industrial techniques. A central national engineering laboratory is well suited for this function since it has a capability for maintaining and mobilizing the needed interdisciplinary talent which would be extremely difficult to establish in smaller labs scattered through a variety of industries. KIST has recently established a Foreign Technology Transfer Consulting Center to coordinate these activities.

Third, while it is neither practical nor necessarily desirable for the central laboratory of a developing country to be completely free from government control, it is certainly desirable that the laboratory be reasonably well insulated from meddling by petty bureaucrats, a complaint one often hears from scientists who work in the developing countries. The Battelle model used at KIST gives the laboratory considerable economic independence, which should provide some buffer against unwarranted interference. It is difficult to say how well this theoretical independence works in practice, since criticism of the government is not encouraged in Korea. I did, however, get the impression that the senior staff at KIST felt that their interaction with the government was, in the balance, constructive.

Fourth, a developing country like Korea must depend heavily on foreign universities for the advanced training of its citizens. It then faces the problem of persuading a reasonable fraction of these highly trained individuals to return and contribute to its industrial development. Its recruitment effort is hampered both by the fact that it cannot offer the high salaries and modern facilities available in research laboratories in the more developed countries and by the reality that it is difficult to persuade trained individuals working at the forefront of their professions to return to take on highly applied problems in industrial processes which are often behind the state-of-the-art in the advanced industrial nations. A centralized facility like KIST offering professional

stature, good facilities, a variety of interesting problems, and attractive living and working conditions must certainly help in the recruitment effort. The qualifications of the senior staff at KIST suggest that recruitment has not been a serious problem.

Aside from evident equipment needs the principal problem I perceived during my brief visit to KIST was a possibly excessive emphasis on short-term projects. A number of the projects which were described to me seemed to be of the trouble-shooting or routine quality control sort which in the United States would be handled on a day-to-day basis by the staff of the affected plant. Referring problems of this sort to a central laboratory not only places them in the hands of engineers who are less familiar with day-to-day plant operations, but most inevitably involves delays in contract negotiation and material and sample transportation which retard the solution to the problem. There is, at the same time, a clear danger that a central research staff will become technically stable if too much of its time is spent in routine work. In looking to the future of a laboratory which seems to have made a fine beginning one would hope the development of Korean industry will include the build-up of good in-house laboratories for the solution of routine problems, allowing the Institute to place more emphasis on systematic approaches to critical long-range industrial needs.

TRENDS IN JAPANESE HIGHER EDUCATION

Morton A. Bertin

This paper was stimulated by a series of critical articles relating to higher education in Japan which recently appeared in the Tokyo press. The subject of Japanese education can be highly controversial. There have been serious contentions, blows struck, even murders and suicides resulting from differences of opinion. The fact that the Japanese take the topic seriously should not be surprising. Though they were late starters, their over-all progress in the past hundred or so years has been tied firmly to educational aims, and vice versa. The trends in education are reasonably consistent with the general pragmatic view of the leaders of government and industry as well as the rank and file. This does not mean that they have always moved or reacted smoothly or readily. Sharply dramatic events: the unification of Japan, the opening of Japan to the world, the defeat of 1945 and such, have mitigated change, caused it to come about sharply, almost by decree. As we shall see, this is not what we are witnessing today. There appears, instead, to be in process an inexorable shift, not so much of values as of approach. The problems are complex and the dissent is far-ranging. Many agree that something is lacking; fallen short of needed goals. Some go so far as to call the system unsound. Possibly it is part of the maturation process, for the modern educational structure in Japan had a very short childhood and adolescence. It grew up fast and is now trying to catch up. It appears an indication of health rather than weakness.

Some weeks ago local newspapers featured the findings of the Committee on Science and Technology of the Organization for Economic Cooperation and Development (OECD), a multi-national group established in 1961 to promote economic, social, environmental, and educational policies among member nations. The committee undertook a study of the social science educational systems in Japan, and concluded that "not only are social sciences in Japan lacking originality, but the great majority of the research in Japan is 'desk' research which uses high-flown, abstract ideas." The report, submitted to the Ministry of Education, is in the nature of a series of recommendations from so-called disinterested third parties and has created quite a furor. In essence, it charges that (1) the Ministry of Education has emphasized engineering and physical sciences and excluded support for the social sciences; (2) there is little creative instruction, teachers simply relying on the parroting of foreign textbooks; (3) student counseling and training in analytical approaches to social problems are lacking and those who seek such basics are forced to travel overseas for training; (4) most research is highly abstract and lacks originality. Recommendations included the establishment of a detailed study by expert sociologists, psychologists and others; the formation of a comprehensive research system by the Japan Science Council; the inclusion of social scientists in the ministries and agencies; and the creation of regional social science research institutes to assure a unified approach.

The report is neither remarkable nor surprising. It is what many social scientists have been saying for years. What is of special interest is the flurry of companion articles and reports triggered by the newspaper item. This is a phenomenon common in Japan, where criticism is taken seriously, not only by those involved, but by individuals and groups only remotely concerned. It isn't a case, as Jimmy Durante used to say, of "everyone trying to get into the act," but more a personalization of involvement. In any event, within a few days of the initial report, there was a spate of editorials and related articles. A group of private university professors issued a statement that the private schools are inferior to the state universities and that the gap is widening. In particular the report charged deficiencies in funding and educational standards. The student to teacher ratio is said to be 39.6 or four times the ratio of the state schools, and most of the former rely on parttime instructors, due to financial reasons.

The Sankei Shimbun, a Japanese language paper, quoted the OECD report that "there are very few Japanese scholars of the social sciences with originality and international reputation." It further asserted that social

science studies have rarely influenced government policy, but have been used by bureaucrats as expediencies required. An editorial in the Mainichi Daily News charged that schools are at a crucial stage whereas Juku, the private preparatory institutes, are thriving. The same newspaper announced that the Ministry of Education has started building all private-room dormitories for students of the national universities. In two adjacent columns, the Japan Times reported that the National Universities Association favors a common entrance examination for all state university applicants; and the adjoining headline said that freshmen find work too hard, but these are not school freshmen, but rather those who have left school and are experiencing their first year of employment after graduation. The Daily Yomiuri bemoaned the fact that about half of Japan's junior high students spend their after-school hours going to some private school so that they can get ahead faster. The Asahi Evening News told of a curriculum reform plan drafted by the Japanese Teachers Union, the slogan being "relaxed lessons and pleasant schools." An editorial in the Japan Times proffered aid and advice to academia, charging that education is losing touch with the real world, asserting that the tried and true ways of the past are no longer relevant. The cry is for a fresh spirit of reform. A column in the Asahi Evening News pointed to the use of academicians in government in the United States as a healthy condition and drew a comparison with the situation in Japan. Many papers featured articles describing the United Nations University, which was established in Japan, stressing the benefits of locating the institution in this country. And finally, Michio Nagai, the Minister of Education, spoke out asserting that recession retards education; he ranged through the problems of the schools and drew a distinction between schooling and education; and in conclusion he pledged to keep out of politics, and in this way assure that education would be unaffected by economic and political changes.

Through all this one wonders what is happening to education in Japan, and where it is heading. The many academicians and administrators to whom I have posed the question are themselves uncertain; the only certainty is that we are witnessing a changing scene. It might be useful, before we look ahead, to take a brief backward glance at the historical development of Japanese educational systems.

As with most things, education grew as a force responsive to the tradition and culture of the country. Possibly more so in Japan than in other countries, for here these factors are more pervasive and over-riding. Prior to the Tokugawa period (1603-1867), schools were the province of the nobility, primarily to provide instruction in the martial arts and the classics. By the seventh century A.D. there are accounts of the establishment of several schools, and even a college with professors and students pursuing academic learning. These were under the administration of the Imperial Court and called for professors of music, the classics, literature, calligraphy, and mathematics. This was seemingly a well organized system with regular classes, examinations, and periodic vacations. Ever pragmatic, the administrators required that at least one fifth of the students be required to take a medical course. It is apparent that education in Japan developed as part of the tradition, though admittedly limited in its early stages to the upper class.

The Tokugawa period represented a shifting from an essentially feudal to a centralized society and heralded the end of the rule of fiefdoms. Education was still class conscious, but commoners were not excluded. It was more than a case of lack of interest on the part of the ruling nobility. A Japanese author, in 1688, wrote that "the art of poetry is for the nobles; that of archery and horsemanship is for the warriors. But the townsmen should excel in computation and learn to keep book punctually." A philosopher of the time admonished sons of merchants to give up the reading of literature and think only of bookkeeping. These are an essential reflection of the times. Japan had entered an era of stable and relatively peaceful government, and the atmosphere encouraged the development and expansion of education. The merchant class had attained a position of social and economic influence, possibly more tacit than openly recognized, and their children could no longer be denied the benefits of education. As an example of the trend, the early schools were established under Confucian scholars; by 1863 an academy was set up to teach Western sciences and language; in 1856 a military school was opened to teach Western artillery, strategy, military arts, and navigation. As with other things, education flowed with the times.

The Meiji Restoration (1868-1912) ushered in a new age for Japan. The nation was unified, the old warrior society disappeared, and new and radical educational reforms were instituted. These paved the way for a true democratization of the educational system and led to the elimination of the fairly rigid structuralization which had been traditional for all the preceding centuries. There was considerable pressure on all to overtake

the advanced countries. Although the first serious analytical scrutiny of western educational systems was started in 1868, by 1870 a unified system was established, patterned after the institutions developed in the west, with faculties of pedagogy, letters, law, science, and medicine. Night schools were established for working students, and for the first time in Japan there were separate colleges for law, medicine, and fine arts. Shortly thereafter a massive exchange program was instituted with western professors being invited to teach in Japan and Japanese students sent overseas to learn modern subject matter as well as methodology. It is probably valid to say that foreigners such as David Murray, an American who was invited to be consultant to the Ministry of Education, left a lasting mark on the educational system and curriculum. The early period was essentially one of trial and error, so far as administrative policy was concerned, but the basic idea of reform remained as a consistent force within the tradition of Japanese morality, manners, and customs.

Undoubtedly the greatest and most enduring influence on modern education in Japan was exerted by the Minister of Education, Arinari Mori (1847-1889), who carried out a complete reform of the entire system. This remarkable man who has been described as the "boldest and most progressive Minister of Education Japan ever had," at age 24 had been the first Japanese Minister to the United States. A great admirer of the American style, he was later assassinated by a fanatic who charged Mori with threatening the traditional values of the throne and country. After World War II, additional reforms were instituted, among them the 6-3-3-4 system, with the six years of elementary and the three of the lower secondary school becoming compulsory. In 1945 there were only 390,000 students enrolled in all schools of higher education, but the boom was on. As I see it we are now in another period of change, change for the better. Signs of the trend are still limited to a few of the more progressive institutions, but more about that later.

To put things into perspective, here are a few statistics taken from the Ministry of Education report for 1975, the latest available. The total number of four year schools of higher education is 420: 81 national, 34 prefectural (state), and 305 private. Of these almost half have graduate departments. Total student enrollment is 1,734,082, 21% national, 3% prefectural, and 76% private. For these four-year universities (including graduate schools) about 21% of the students are female. (The ratios are about reversed for the two-year schools.) In terms of subject matter majors, 42% are in social sciences, 20% engineering, 13% humanities, 7% education, 3% natural science, 4% health sciences, other disciplines comprising the balance. The number of fulltime teachers is 89,648 with the national and private schools sharing about equal numbers. Parttime teachers amount to 57,646; 17,245 national, 37,235 private, the balance prefectural. The teacher to student ratio for the national schools is 8.5 to 1, for the private 31.5 to 1.

There are background factors which have created certain stresses on the system. Historically, a university diploma has been an admission ticket to a career in government or industry. Certain schools traditionally provide graduates for one or the other. The more prestigious the school, the higher the job potential. Competitiveness in most Japanese universities largely ends with admission. Getting in is the battle, staying in (unlike in the United States) is no problem. In a strange way this has led to a unique democratization. Merit is the key to admission to the system, and a destitute student who passes the national university examination can rise far above his affluent peer who fails. There is some evidence that this does not hold in the same way for those entering many private medical and dental schools, where apparently large donations are required before a student will be considered for admission.

Looking at the statistics presented earlier, it is apparent that there is a sharp imbalance between the so-called hard science graduates and those in the fields of social science and humanities. Michio Nagai, present Minister of Education, stresses the need for more scientists and engineers. A possible explanation for the imbalance is economic. We see the type of preferred degree fluctuate in the United States as the job market varies. In Japan unemployment is not a serious problem. Almost everyone who graduates will find a job, and for whatever reason, most students opt for the "softer" career, possibly the less rigorous curriculum.

It was stated earlier that this is a period of change and I would like to examine some of the factors which may have led to the first signs of a movement away from the established pattern. The Imperial University Ordinance of 1886 decreed that "The purpose of the imperial university shall be to provide instruction in the arts and sciences and to enquire into the mysteries of learning in accordance with the needs of the state." This

statement of a basic reason for existence was not concurred in by all, nor is it today. The founder of Keio University felt that the intellectuals formed an elite and should be above the day to day problems, concentrating instead on more esoteric planes. Private universities took the lead in striving for academic freedom and the dropping of governmental controls, and the Waseda riots of 1917 were perhaps a forerunner of things to come. These did not represent a strong unified movement, either by the private or national schools, nor were the faculties or students of the more activist schools united in goal or philosophy.

There is no doubt that the violent, frequently bloody, surge of student upheaval in the late 60's and early 70's was triggered by similar movements in other countries, but the turmoil in Japan had some unique characteristics. It lasted longer and took on the atmosphere of something resembling group self-destruction. I have visited laboratories where simple home-made equipments were spared, but everything of value was destroyed. In some cases these were smashed beyond simple destruction, as though the material represented a hated object against which the students vented their spleen. Discussions with numerous academicians have resulted in bewildering interpretations. Perhaps this form of self-destruction was a cry of outrage at the seeming uselessness of it all. For students whose goal since earliest years was admission to some prized institution, wherein membership alone was the key to a successful future, the reality of the limited campus stimulation had to be shattering. Some feel that things are back to normal, and as they were before, but it appears that basic and important changes have indeed taken place.

Actually, the seeds of change had undoubtedly been sown long since, and whether the student riots hastened the process is moot. It should also be recognized that the change, though substantial, is far from sweeping. Also, there is a wide diversity of opinion on the relative benefits to be derived from altering the system. Interestingly enough, the young Turks are not always young and some of the senior professors are looking with favor at the possibility of a break with some of the traditions. A crack has begun to appear in the traditional pattern of the chair system in certain universities. There are indications that as the old line professors move out, the incumbents will bring with them a less empire-oriented structure.

There has been a definite "breaking away" on the part of graduate students from the narrow channel of research, the traditional follow-in-the-footsteps syndrome, and in psychology this seems to be happening with the blessing of the teacher. I have witnessed an interesting phenomenon, wherein professors with long careers in perceptual research find new and challenging stimulation in the diversity of their students' programs. Though still the exception, it appears to be increasing. Until quite recently most of the research of graduate students which I observed was largely imitative, but this too seems to be slowly changing. In recent years one sees more original work, particularly in the emerging fields of psychology. On this subject, there is a strong and noticeable expansion in the scope of the fields of psychology in most of the universities.

The traditional employment pattern is for the universities to hire their own graduates and for them to remain in the same school for almost their entire teaching career, at least until retirement. Rarely, in the past, would a professor move to another university. A young instructor was essentially hired for life, moving up as his superior moved up and out. This is a facet of the chair system, and administratively has some advantages. For quality education it appears to be a drawback, and it has disappeared in several schools.

A striking innovation for Japan and a hopeful sign for the future has been the establishment of Tsukuba University, briefly described in my article in the last issue of this publication. As the academic segment of Tsukuba Newtown, Japan's science city and counterpart to the Soviet Union's Akademgorodok at Novosibirsk, Tsukuba University was founded on principles highly revolutionary for Japan. It is being built on the foundations of Tokyo University of Education, which is in the process of moving to Tsukuba, but under strikingly innovative guidelines. A departure from the general administrative structure is a centralized authority, vested in a Chancellor and five vice-presidents, who form a policy group under which the university operates. The chair system has been essentially eliminated and a break in the traumatic admission examination has appeared in that 20% of the students enter the university on the basis of their high school records and recommendations. The success of these students will be compared with those entering via the traditional route, opening the possibility of an eventual expansion of the procedure. It is likely that should this prove successful, other national schools will follow suit. The structural organization has likewise been uniquely developed

into a cluster system, such that the physical layout of the campus is designed to group together related discipline areas. For example, Cluster I contains the basic sciences and includes the humanities, the social sciences, and the natural sciences. The intent is to provide logically interactive groupings, sharing common library and other facilities, so that the students can easily pursue interdisciplinary aims.

The entire concept of establishing a school of this nature in a complex of research institutes appears to be encouraging for the future of higher education in Japan. The idea has not met with general approval, particularly on the part of the well ensconced academicians, who apparently regard it as a threat to an establishment that they feel has proven highly successful. The primary resistance seems to lie in the centralization of authority and the essential abdication by the senior faculty. Tradition dies hard in Japan; only time can show how pervasive is the trend and whether it will persevere.

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